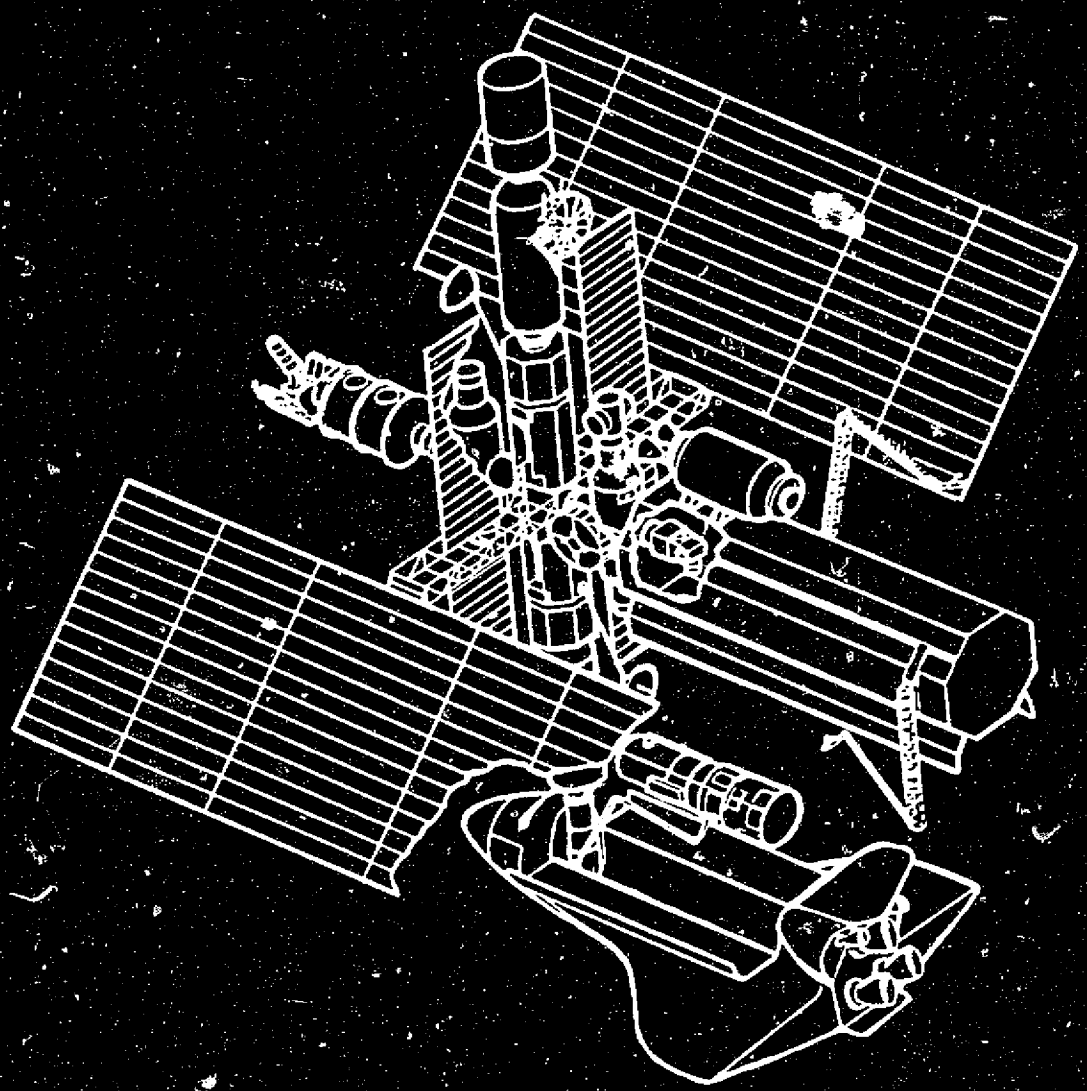


Space Station Needs, Attributes, and Architectural Options Study

MARTIN MARIETTA

Contract NASW-3686

November 1982

SPACE STATION NEEDS ATTRIBUTES AND ARCHITECTURAL OPTIONS

BRIEFING MATERIAL
MID-TERM REVIEW

Prepared For:

The National Aeronautics
and Space Administration (NASA)
and The Department of Defense (DOD)

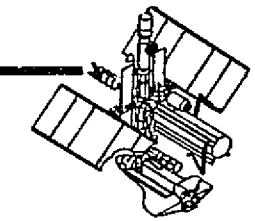
Prepared By:

Martin Marietta Aerospace
Denver Aerospace
Space and Electronics Systems Division
P. O. Box 179
Denver, CO 80201

Program Manager: Sherman R. Schrock

FOREWORD

This document is submitted in accordance with the requirements of Contract NASW-3686, Schedule Article II, and Contractor Task 5.2 of Attachment A Statement of Work. This document is the briefing material for the mid-term review.



Mid-Term Review

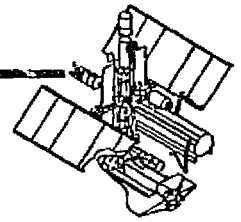
Space Station Needs, Attributes

And

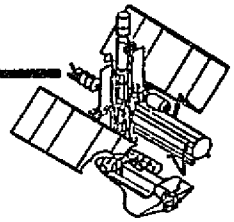
Architectural Options

MARTIN MARIETTA

Agenda



SUBJECT	SPEAKER
Introduction	R. B. Demoret
Executive Summary	S. R. Schrock
Mission Requirements	T. J. Sullivan
- User Mission Requirements Development	F. J. Steputis
- Astronomy/Space Physics/Planetary	F. Bartko
- Solar Physics/Earth Observations	S. M. Pompea
- Comm./Life Sci./Mtls Proc./Commercial	W. O. Nobles
- Space Station and User Requirements Analysis	G. E. Stone
- Accrued Benefits	T. J. Sullivan
Mission Implementation Concepts	T. J. Rasser
Cost, Schedule, and Benefits Analysis	T. A. Mottinger
DOD Tasks	T. K. Sulmeisters
Adjournment	



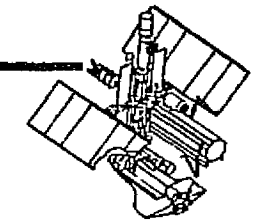
Executive Summary

Space Station Needs, Attributes

And

Architectural Options

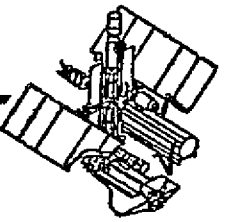
Executive Summary



AGENDA

- PROJECT ORGANIZATION
  - SUBCONTRACTOR SUPPORT
    - PROGRAM SCHEDULE
      - STUDY FLOW
        - USER MISSION DATA DEVELOPMENT
          - REQUIREMENTS DEVELOPMENT
            - MISSION IMPLEMENTATION CONCEPTS
              - COST/SCHEDULE/BENEFITS ANALYSIS
                - TECHNOLOGY ASSESSMENT
                  - FOREIGN USER DATA
                    - DOD TASKS
                      - STUDY SUMMARY

Project Organization



Space Station Needs Attributes & Architectural Options Study

Program Manager
Sherman R. Schrock

Executive Management Council

- R. J. Polutchko, Chairman, VP & Gen Mgr, Space & Elec Sys, Denver Aerospace
- A. T. Young, VP Res & Eng, Martin Marietta Aerospace
- K. P. Timmons, VP & Gen Manager, Michoud Div
- J. W. McAnally, VP Tech Ops Denver Aerospace
- P. B. Teets, VP Bus Dev, Denver Aerospace
- J. W. McCown, VP Advanced Space Launch Sys, Space Launch Sys Div, Denver Aerospace
- A. M. Norton, VP Development, Michoud Div
- J. L. Burridge, VP & Chief Engineer, Denver Aerospace

Science Mission Panel

- K. J. Coughlin, Denver Aerospace, Chairman
- Dr. G. Columbo, Univ of Padua
- R. Gibson Martin Marietta Corp, London
- Dr. R. Goody, Harvard Univ
- Dr. D. Hunten, Univ of Arizona
- Dr. R. Johnston, Texas Medical Center, Inc
- Dr. D. Koelle, MBB, Germany
- Dr. M. McElroy, Harvard Univ
- Dr. G. Pettengill, MIT

Product Development
Manager
T. J. Sisk

Michoud Interface
B. F. Elam

Business Management
Manager
M. M. Bretting

Mission Requirements
Manager
T. J. Sullivan

Ball Aerospace
R. M. Scott

USRA J. Sevier

F. Steputis, F. Bartko, K. Bradford, J. Freidell, L. Henton, J. Mill

S. Pompea, S. Wenger, A. Wildgen, G. Stone, A. Fier, S. Goudy

B. Marcy, M. Merriken, G. Noonan, J. Trottner, A. Vandenburgh, A. Wudell

Michoud: C. Ewing

Mission Implementation Concepts
Manager
T. J. Rasser

Hamilton Standard
A. O. Brouillet

C. Brayton, J. Leritz, B. Lockhart, G. McAllister

N. Miyake, J. Navarra, R. Skidmore, V. Thomas

Michoud:
J. deGeneris, W. Gilmore
M. Dillon, P. Mitchell

Cost & Programmatic Analysis
Manager
T. A. Mottinger

D. Eimers
C. Johnson

Michoud:
R. Ernst
T. Tanksley

DOD Task Assignment
Manager
T. K. Sulmeisters

INFOTEC
R. Horrigan

J. Trottner
D. Wenger
B. Wilde

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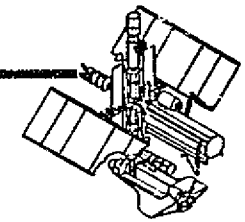
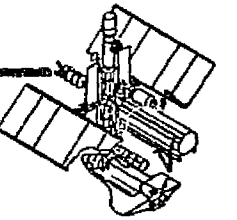
Science Missions Panel



- Panel Make-Up
  - Internationally known scientist and aerospace leaders.
- Tasks
  - User requirements understanding and development.
  - User requirements projection.
  - Validation of time-phased science objectives.
  - Instrumentation and Operations.

Executive Management Council



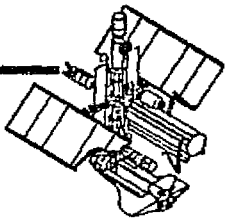
- Purpose

  - Assure infusion of corporate ideas and knowledge:
    - Gain active participation and interest of top corporate decision makers in the space station program.
    - Gain broad perspective through management's contacts with leaders from industry and government.
    - Bring to bear expertise in broad fiscal planning.

- Specific Tasks

  - Strategies to develop user consistency.
  - DOD implication and requirements.
  - Industry involvement in Space Station.
  - Review study results.

Space Station Subcontractors



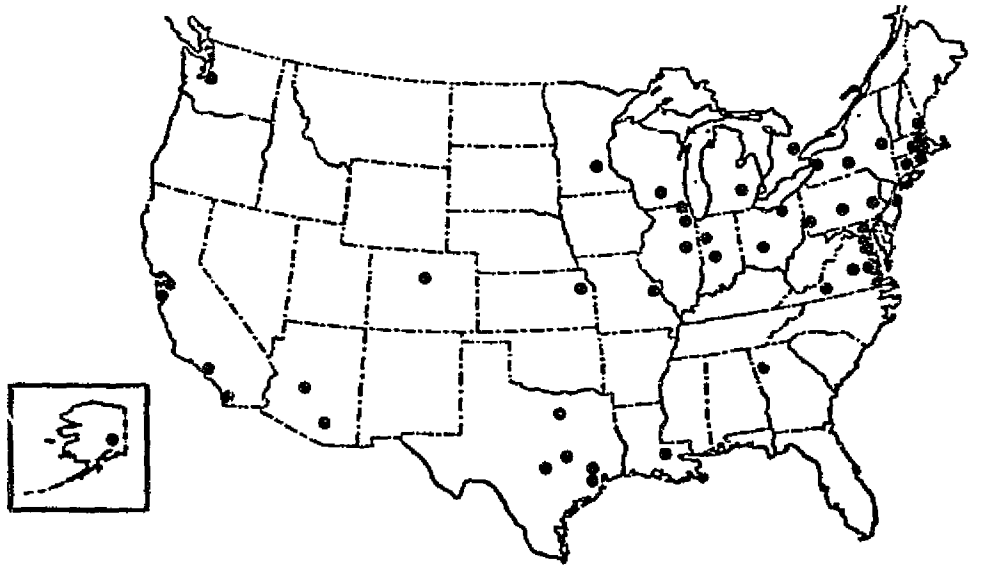
BALL AEROSPACE

- USER MISSION REQUIREMENTS DEVELOPMENT
  - SOLAR
  - COMMERCIAL
  - EARTH RESOURCES
  - APPLICATIONS

UNIVERSITY SPACE RESEARCH ASSOCIATION (USRA)

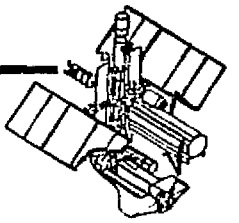
- USER MISSION REQUIREMENTS DEVELOPMENT AND VALIDATION
  - ATMOSPHERIC SCIENCES
  - ASTRONOMY
  - SPACE PHYSICS
  - LIFE SCIENCES
  - REMOTE SENSING
  - MATERIALS PROCESSING

USRA Member Institutions



Alaska, University of
Arizona State University
Arizona, University of
Boston College
Brown University
California, University of (Berkeley)
California, University of (Los Angeles)
California, University of (San Diego)
Case Western Reserve University
Chicago, University of
Cornell University
Denver, University of
Georgetown University
Georgia Institute of Technology
Harvard University
Houston, University of
Illinois, University of (Urbana)
Indiana University
Johns Hopkins University
Kansas, University of
Lehigh University
Louisiana State University (Baton Rouge)
Maryland, University of (College Park)
Massachusetts Institute of Technology
Michigan, University of (Ann Arbor)
Minnesota, University of (Minneapolis)
New Hampshire, University of
New York, State University of (Buffalo)
New York, State University of (Stony Brook)
New York University
Northwestern University
Ohio State University
Old Dominion University
Pennsylvania State University
Pittsburgh, University of
Princeton University
Purdue University
Rensselaer Polytechnic Institute
Rice University
Rockefeller University
Stanford University
Texas A & M University
Texas, University of (Austin)
Texas, University of (Dallas)
Toronto, University of
Virginia Polytechnic Institute and State University
Virginia, University of
Washington, University of
Washington University (St. Louis)
William and Mary, College of
Wisconsin, University of (Madison)
Yale University

Space Station Subcontractors (Cont'd)



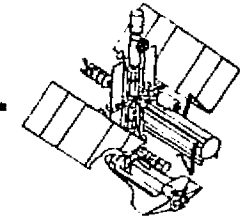
INFOTEC DEVELOPMENT INC (IDI)

- DEFINITION OF DOD INFRASTRUCTUE COMMUNICATION INTERFACES
  - PROJECTED AFSCN TO AND BEYOND YEAR 2000
  - WAYS TO USE SPACE STATION WITHIN THE AFSCN
  - SPACE STATION INTERFACES OR ENHANCEMENTS OF SPECIFIC DOD SPACE PROGRAMS

HAMILTON STANDARD

- SPACE STATION ARCHITECURE, COST, AND SCHEDULES
  - ENVIRONMENTAL CONTROL SYSTEMS
  - LIFE SUPPORT SYSTEMS
  - HABITABILITY
  - EVA SYSTEMS

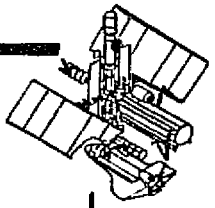
Study Schedule

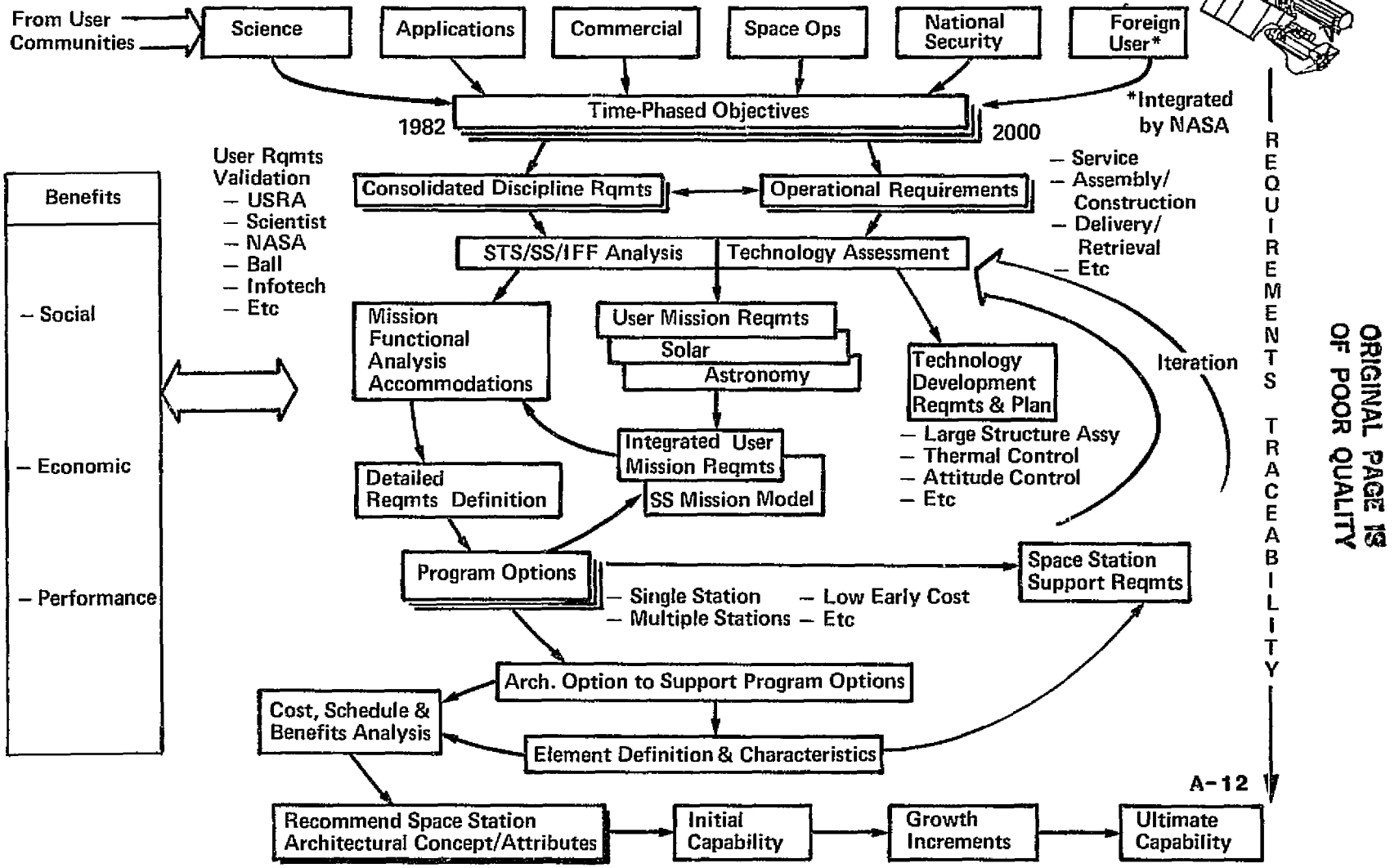


	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR
MAJOR REVIEWS & REPORTS 8/23/82 ATP	▲▲	ORIENT.MTG. 8/26	MID TERM	11/16		FINAL 2/21/83	△DRAFT	△ FINAL△ REPORT
MONTHLY STATUS REPORTS		▲9/27	▲10/27	△11/29	△12/23	△1/28	△2/28	4/22
EXECUTIVE MANAGEMENT REVIEW COUNCIL MEETINGS								
3.1.1 USER MISSIONS			▲P					
3.1.2 USER MISSION REQUIREMENTS			▲P					
3.1.3 REQUIREMENTS RELATIONSHIP TO CURRENT STS			▲P					
3.1.4 SPACE STATION USER ACCOMMODATION REQUIREMENTS			▲P					
3.1.5 MISSION ALTERNATIVES AND ACCRUED BENEFITS			▲P					
3.2.1 PROGRAM OPTIONS				△P				
3.2.2 SYSTEM ATTRIBUTES AND CHARACTERISTICS				△P				
3.2.3 RECOMMENDED EVOLUTION PLAN								
3.3.1 SCHEDULE ANALYSIS			▲P					
3.3.2 COST AND BENEFITS ANALYSIS			▲P					
3.4.1 SPACE STATION INTERFACES WITH DOD SPACE INFRASTRUCTURE								
3.4.2 DOD'S INVOLVEMENT WITH THE STS								
3.4.3 DOD OPERATION WITH THE SPACE STATION								
3.5.1 NASA PERFORMANCE REVIEWS AND DOCUMENTATION								
3.5.2 DOD PERFORMANCE REVIEWS AND DOCUMENTATION								

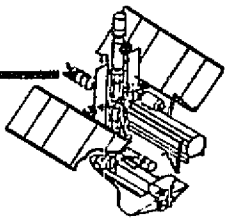
MARTIN MARIETTA

Space Station Study Flow





User Mission Data Development



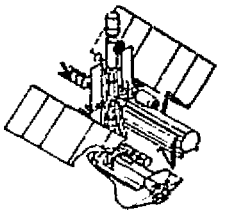
Approach

- Qualified Personnel
- Comprehensive Contact Plan
- Services of Recognized Experts/Subcontractors
- Define Long-Range Objectives and Implementation Concepts
- Design Concepts to Take Advantage of SS Special Capabilities
- Data Validation/Traceability

Results

- 112 Personal Interviews
- 99 Phone Interviews
- 20-Year Objectives/Implementation Concepts
  - Solar Physics
  - Astronomy
  - Earth Observations
  - Planetary
  - Materials Processing
- Operational Support Requirements
- Technology Development Requirements
- USRA Panel and Consultant Meetings
- Interviews have Generated Interest and Gained Support for SS

Astronomy User Missions

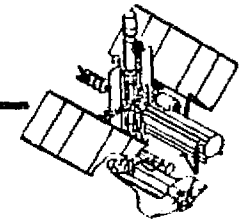


Candidate Astronomy Missions

- Large Deployable Reflector (LDR)
- Space Telescope (ST)
- Large Area Modular Array X-Ray Telescope (LAMAR)
- X-Ray Timing Explorer (XTE)
- Advanced X-Ray Astrophysics Facility (AXAF)
- Extreme Ultraviolet Explorer (EUVE)
- Gamma Ray Observatory (GRO)
- X-Ray Observatory (XRO)
- Starlab
- Shuttle Infrared Telescope Facility (SIRTF)
- Cosmic Ray Observatory (CRO)
- Orbiting Very Long Baseline Interferometer (OVLBI)
- Gravity Probe-B (GP-B)
- Cosmic Background Explorer (COBE)
- Orbiting Infrared Submillimeter Telescope (OIST)
- Infrared Interferometer
- Gravity Wave Interferometer
- Coherent Optical System of Modular Imaging Collectors
- 100-m Thinned Aperture Telescope (TAT)
- Very Large Space Telescope (VLST)
- Heavy Nuclei Explorer (HNE)

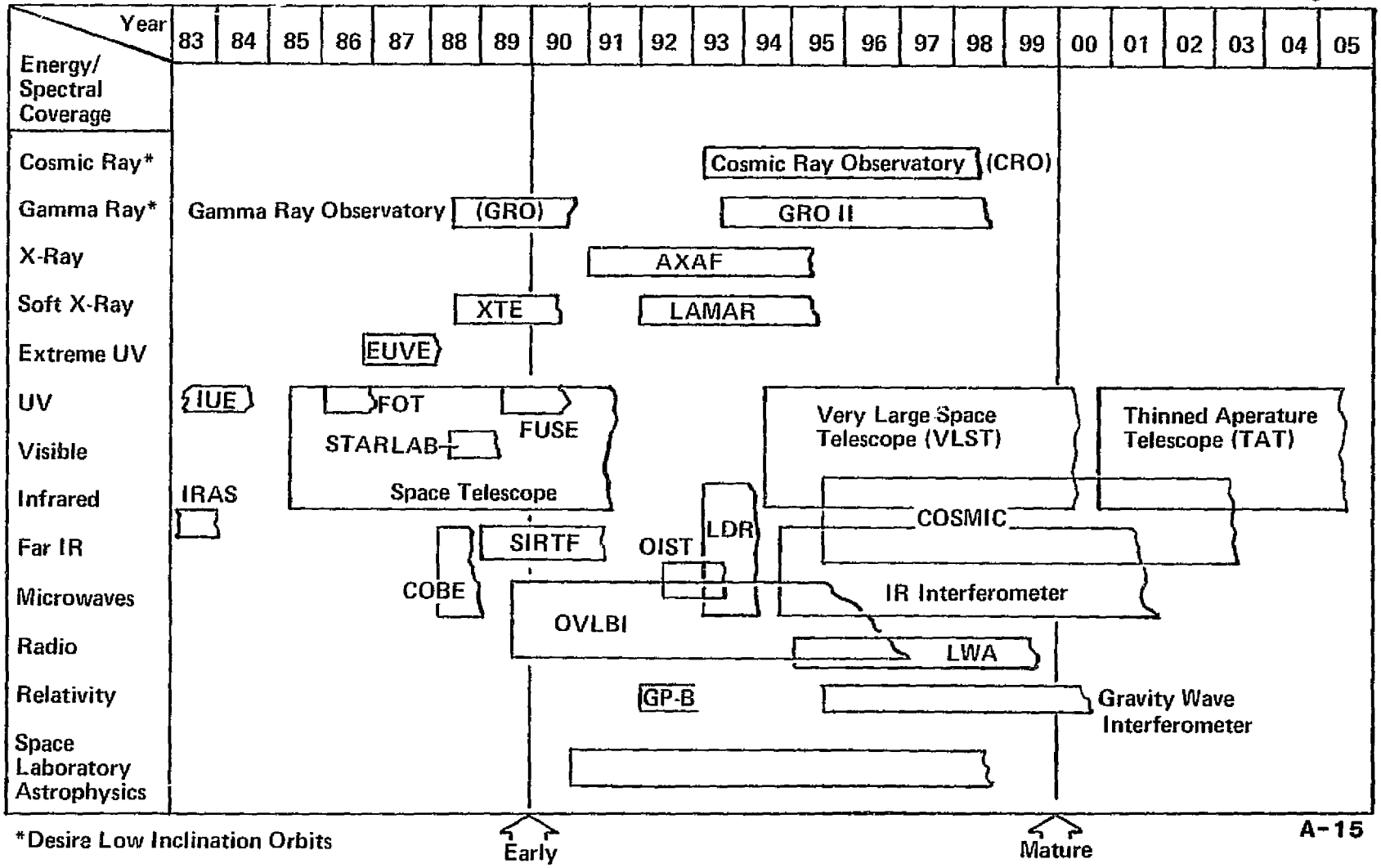
→ Astronomy Missions for 20-yr Projection

Astronomy Mission Sequence



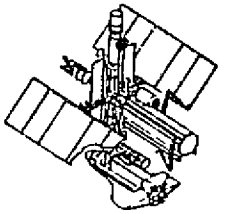
Emphasis on Broad-Spectrum Coverage

Illustrates Evolution to Next Generation Set of Requirements



*Desire Low Inclination Orbits

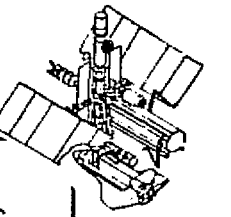
Critical Integration Requirements



Astronomy	Early Phase	Mature Phase
Orbit	40°-57°	28.5°
Dimensions (m)	40 Diameter	100 X 10
Weight (kg)	27,000	85,000
Pointing/Control (sec)	10^{-2} Stability	10^{-4} Stability
Data (bits/day)	10^{12}-10^{14}	10^{14}
Power (kw)	3	7
Crew	2-6	7-10

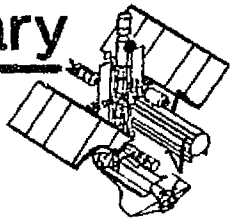
Space Physics		
Orbit	90°	GEO
Dimensions (m)	80 X 15 X 9	2000 Diameter
Weight (kg)	50,000	50,000
Pointing/Control (sec)	10^{-2}	10^{-2} Stability
Data (bits/day)	10^{11}	10^{12}
Power (kw)	15	25
Crew	2-6	6

Results – Operational Support Requirements



Example Missions	Early Phase Operational Capabilities	Example Missions	Mature Phase Operational Capabilities
EUVE, COBE, XTE, FUSE	Deployment/Retrieval Maintenance/Servicing	VLST	Assembly, Construction with External Tank Shell
		COSMIC	Assembly, Alignment, & Phasing of Array
GRO, SIRTF, STARLAB, ST	Instrument Changeout: Film/Cryogen Replacement	TAT	Major Construction/Assy, Alignment, and Test
AXAF, OVLBI, LDR	Major Deployment, Assembly, Alignment, Construction, Test		

Space Station And User Requirements Summary



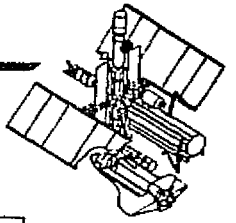
OBJECTIVE

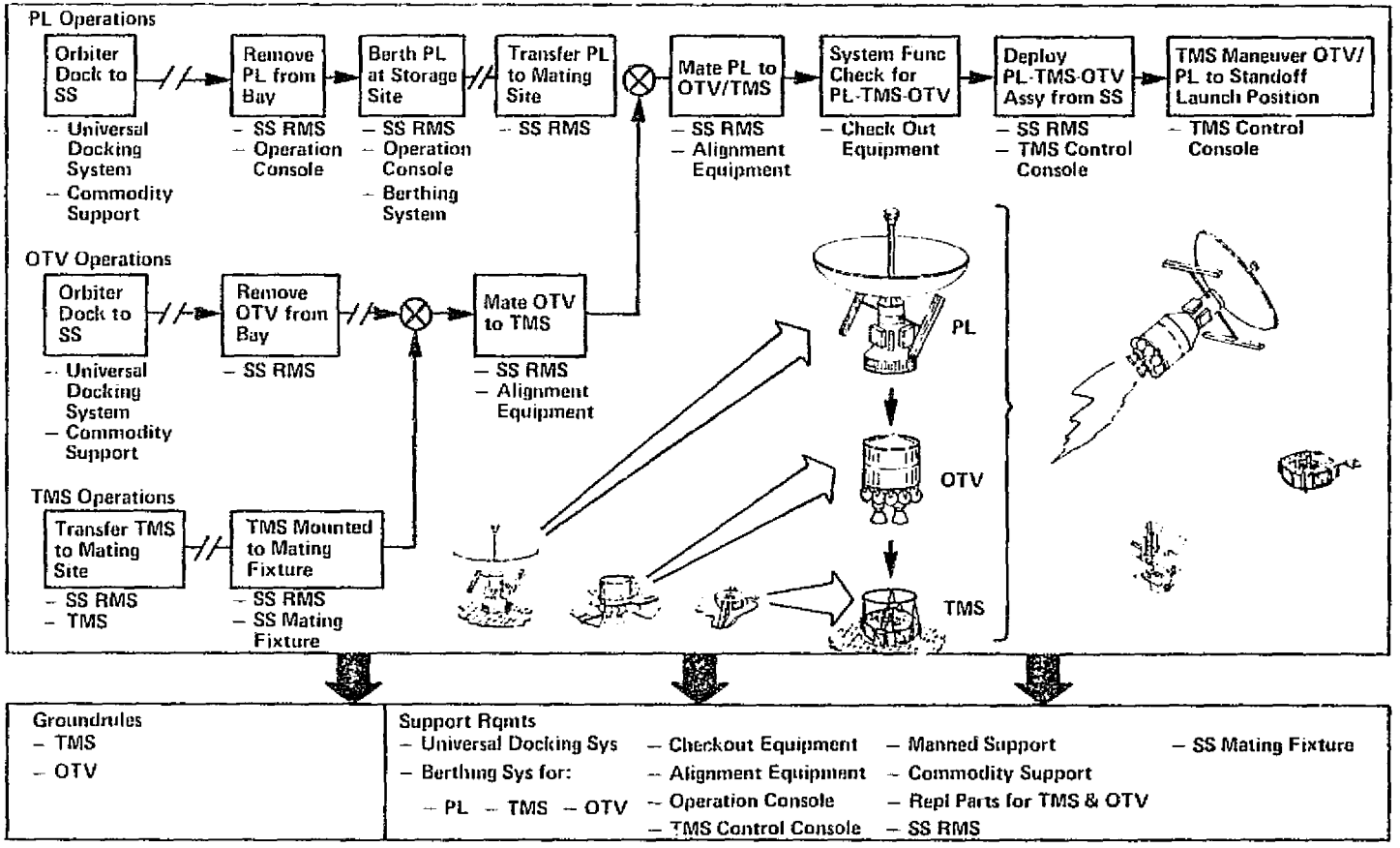
DEVELOP OPERATIONAL AND SYSTEM REQUIREMENTS THAT FORM THE BASIS OF OUR MISSION IMPLMEENTATION CONCEPTS

- SATISFY USER NEEDS
- ESTABLISH ACCOMMODATION REQUIREMENTS

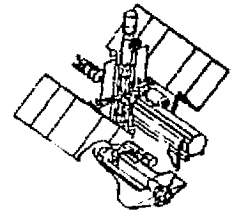
TASKS	RESULTS
• DEVELOP COMPOSITE MISSION MODEL	• INITIAL ISSUE RELEASED - UPDATED AS REQUIRED BY USER DATE
• EVALUATE STS/SS ELV RELATIONSHIP	• INITIAL EVALUATION 40% COMPLETE
• DEVELOP INTEGRATED USER REQUIREMENTS	• INITIAL DOCUMENTS RELEASED - BASIC SS REQUIREMENTS - POTENTIAL USER SUPPORT FUNCTIONS EVALUATED
• EVALUATE ALTERNATIVE MISSION APPROACHES AND REQUIREMENTS	• PRELIMINARY ORBIT SELECTION PARAMETRIC DATA
• PROVIDE REQUIREMENTS TRACEABILITY	• MAINTAINED BY CODE TO MISSION MODEL

Functional Analysis–Assembly PL To OTV



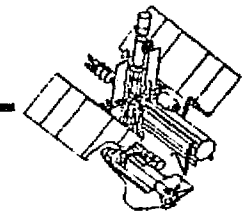


Mission Implementation Concepts



- Define Candidate Program Options
  - Perform feasibility analyses to determine viable program options.
- Analyze Architectural Concepts
  - Define space station characteristics.
- Recommend Evolution Plan
  - Define initial and ultimate capability.

Program Options

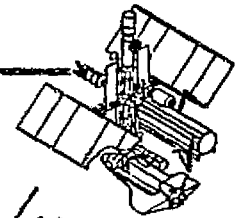


DEFINITION - TOP LEVEL PLAN FOR IMPLEMENTING AND EVOLVING SPACE STATION CAPABILITIES.

RESULTS - SEVEN CANDIDATE PROGRAM OPTIONS DEFINED.

- FOUR OPTIONS
  - EACH CONSISTING OF A MANNED SPACE STATION PLUS ONE OF MORE UNMANNED PLATFORMS.
- THREE OPTIONS
  - EACH CONSISTING OF TWO MANNED SPACE STATION PLUS ONE OR MORE UNMANNED PLATFORMS.
- SPECIAL EMPHASIS
  - IDENTIFY MODEST COST START UP OF SS.

Option A-1: 28.5°- Early OTV



DOD &
GEO Commercial

OTV Retrievable
- Aerobrake
- High Inclin PLs

≪STS/ELV Launches

Science & Matl
Processing
Free Flyers

Servicing-28.5°
- Robotics
- EVA/IVA
- Crew Increase
- LSS Assembly

< STS Service

Science
- System Bus
- Pointing
- Cryo Supply
- Data Process

Platform(s)-28.5°
- DOD Integration

< User Costs
STS Support

Matl Processing
- Resupply
- Maintenance
- System Bus

Platform(s)-28.5°
- Low g
- Attached/Free Flyer

< STS Support

GEO Science & Coml
Planetary

OTV-Retrievable
- GEO
- 50° PLs
- Hangar
- Prop Storage/Transfer
- Scavenging

< STS Support - 28.5°/50° & GEO

Early Payloads

Manned Station
- TMS/Prop Storage
- Crew 3-5
- Servicing (MMU)
- DOD Integration

< STS Support PLs - 28.5°

> STS Support - Station

STS/ELV Support

Capability

1989 1991 1993 1995 1997 2000

Time, Years

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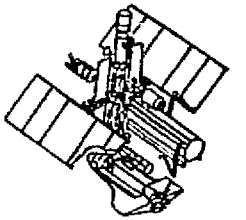
Option B-1: 28.5° → 90° Stations



GEO

OTV Retrievable - 28°

≪ STS & ELV Launches

– Prop Storage/Scavenging
– Crew △ – High Inclin PLs

Science

Servicing - 90°

< STS Service

– Hangar – LSS Assy
– EVA/IVA – Crew
– Robotics

Science & DOD

Manned Station - 90°

< Support - 90° PLs
> STS Support Station

– TMS – DOD Secure
– Crew 3-5 – Servicing

Matl Processing & Science

Servicing - 28 5°

– Hangar – LSS Assy
– Robotics – EVA/IVA
– Crew

Matl Processing

< STS Support
< User Costs

Platform - 28.5°

– Low g

Early Payloads

Manned Station - 28.5°

< STS Support - 28.5° PLs
> STS Support - Station

– TMS/Prop Storage – Servicing
– Crew 3-5 – DOD Integ

STS/ELV Support

Capability →

1989 1991 1993 1995 1997 2000

Time, Years

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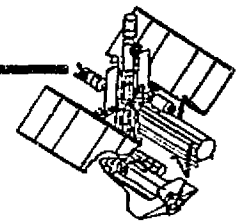
Cost/Schedule/Benefits Analysis



TASKS

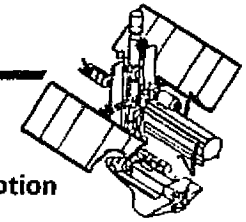
- DEFINE ROM COSTS AND SCHEDULES.
  - ROM COSTS AND SCHEDULES IDENTIFIED FOR 23 ELEMENTS.
  - REFINING COSTS AND SCHEDULES.

- DEVELOP METHODS AND CONDUCT ANALYSES TO DETERMINE ROM COSTS AND BENEFITS OF EACH PROPOSED CAPABILITY INCREMENT
  - COMPLETED FIRST CUT AT ROM COSTS BY PROGRAM OPTION.
  - COMPLETED A METHOD OF DETERMINING ECONOMIC BENEFIT OF ATTACHED USERS.
  - DEVELOPING METHODS TO DETERMINE ECONOMIC BENEFITS OF OTHER CAPABILITIES.

- COMPARE COSTS AND BENEFITS TO DETERMINE A COST-EFFECTIVE EVOLUTION PLAN.
  - DEVELOPED A METHOD OF RATING AND WEIGHING BENEFITS BY PROGRAM OPTION TO DETERMINE COST-EFFECTIVENESS.

- EXPLORE THE EFFECT OF SCHEDULE VARIATION ON COSTS AND BENEFITS.
  - TASK WILL START AFTER MID-TERM REVIEW.

Technology Assessment



OBJECTIVE

To identify key technologies affecting the implementation of user mission requirements and the space station option development, cost, and schedule.

APPROACH

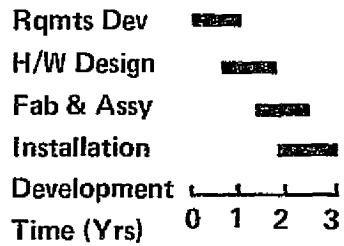
Manned Space Station - 1989
Satellite Servicing - 1989
OTV - 1991
Space Platform(s) (Matl Processing) - 1993
Space Platform(s) (Science) - 1995
Retrievable OTV - 1999

OPTION A-1 (28.5° EARLY OTV)

SATELLITE SERVICING
- Long-Term Nitrogen/Helium/Hydrazine Storage
- Fluid Transfer & Gauging
- Manipulators/Robotics
- Rendezvous/Station-Keeping Contamination
- Minimization Systems
- Automated Docking Systems
- Telepresence Hardware

TELEPRESENCE HARDWARE
- Predictive Controls & Displays
- Force Feedback Tools
- Remote Manipulator(s) Hand Controller
- Telepresence Control Station
- Assorted Manipulator End-Effectors
- Stereo Television

TELEPRESENCE CONTROL STATION



RESULTS
- 40 User Missions Analyzed
- Options A-1, A-2, and A-3 Analyzed

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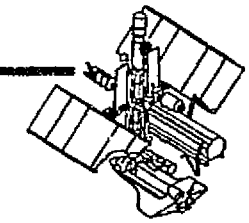
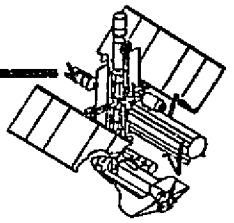
Foreign User Mission Data



FROM CONTRACT SOW:

- STUDY OBJECTIVES
  - THE MISSIONS AND THE CORRESPONDING SPACE STATION REQUIREMENTS ARE TO BE DEVELOPED IN CLOSE COOPERATION WITH POTENTIAL DOMESTIC AND FOREIGN USERS OF THE SPACE STATION.
- MISSION REQUIREMENTS
  - THE CONTRACTOR SHALL CONSIDER, AS A MINIMUM, THE FOLLOWING CATEGORIES OF DOMESITC AND FOREIGN MISSIONS.
- GROUNDRULES AND GUIDELINES
  - THE MISSION OF INTEREST SHALL INCLUDE DOMESTIC AND FOREIGN SCIENCE, APPLICATIONS, AND COMMERCIAL USERS, AS WELL AS U.S. NATIONAL SECURITY, AND SPACE OPERATIONS MISSIONS.

Contacts, Discussions And Meetings



ESA
- J. Collett
  - Prog Mgr Space Station
- R. Mory
  - Long-Term Office
- G. Peters
  - Space Transportation Sys
- U. Huth
  - ESA Matl Proc Discipline Lead
- G. Duchossois
  - Earth Observation
- H. Olthof
  - Astro Sciences
- G. Van Reek
  - Administration

Austrian Space Agency
- H. Ortner

Greek Space Research Center
- M. Moutsoulas

Italian Space Agency
- C. Buonguorno
  - Guernio
  - Monanini
  - Napolitano

Aeg Telefunken
- H. Koebel

Aeritalia
- E. Vallerani
- F. Bevilacqua
- G. Viriglio

Aerospatiale
- G. Leroy
- P. Lucan
- G. Roche

Dornien
- A. Skoog

ERNO
- H. Hauffman
- H. Kappler
- U. Pollnoght
- N. Gentzen
- H. Eusfeld

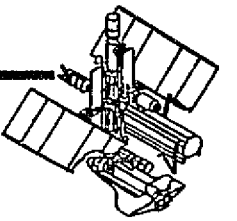
Matra
- J. Battistella
- R. Da

SPAR (Canada)
- R. W. Neville

Indonesia
- H. Djojodihardjo

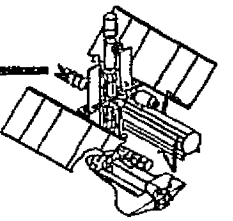
Japan
- H. Matsumiya
- H. Saiki

Foreign Interfaces

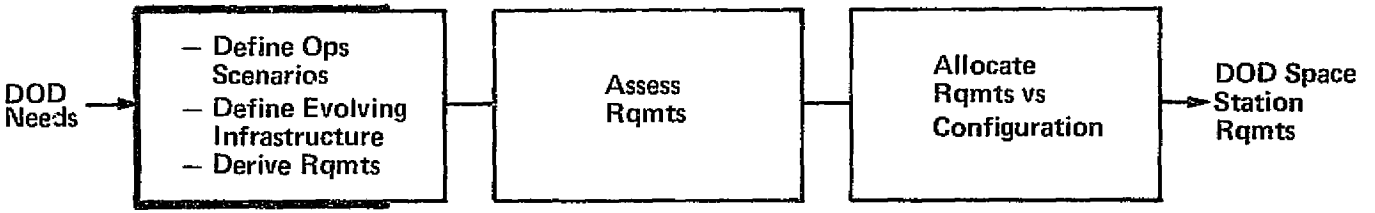


- STATUS
  - FOREIGN COMPANIES CONTACTED REQUESTING WORKING AGREEMENTS WITH US.
  - DIFFICULTY IS THE TECHNICAL DATA FLOW FROM US TO A FOREIGN COUNTRY.
  - DIRECTION IS NEEDED TO PROCEED.

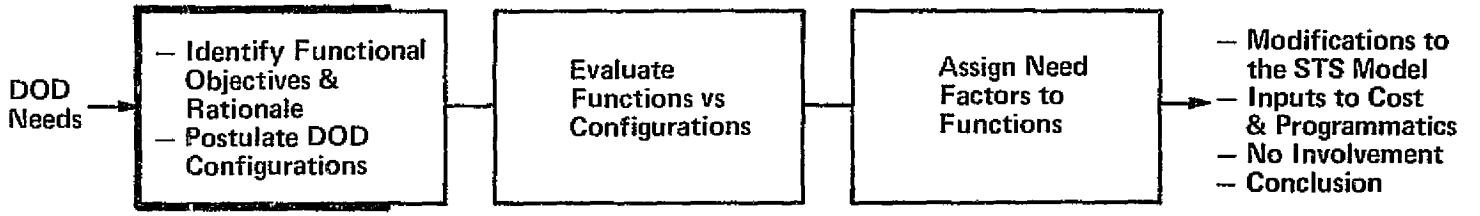
DOD Task Assignment Approach



SPACE STATION INTERFACES WITH DOD SPACE INFRASTRUCTURE



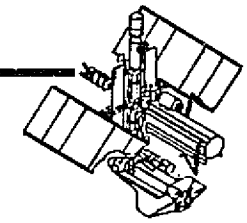
DOD INVOLVEMENT WITH THE STS



DOD OPERATION WITH THE SPACE STATION

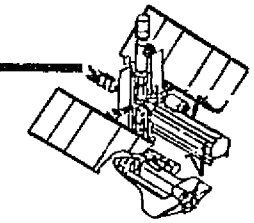
Completed Activity

DOD Task Assignment Accomplishments



- Assessed the Available Threat Model
- Identified DOD Needs
- Defined Some Operational Scenarios
- Documented Existing Infrastructure Internetting
- Identified DOD Functional Objectives
- Postulated Potential DOD Space Station Architecture Options
- Assessed Potential DOD Missions
- Derived DOD Space Station Top-Level Requirements

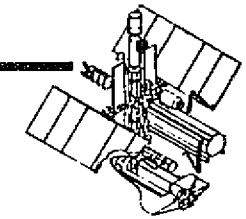
Study Summary



- PROGRESS
  - FULLY MANNED TO PLAN.
  - SUBCONTRACTORS AND CONSULTANTS WORKING WELL.
  - ALL TASKS ON OR AHEAD OF SCHEDULE.

- RESULTS
  - SCIENCE AND APPLICATIONS USER REQUIREMENTS PROGRESSING RAPIDLY.
  - NEW APPROACH BEING IMPLEMENTED FOR SPACE PROCESSING.
  - 290 MISSIONS WITH 450 FLIGHTS DEFINED TO DATE.
  - MANNED SPACE STATION SHOULD PROVIDE MAJOR ECONOMIC AND MISSION BENEFITS TO WIDE VARIETY OF UNMANNED PROGRAMS.
  - MANNED SPACE STATION CAN REDUCE REACTION TIME FOR TIME CRITICAL DOD SPACE MISSIONS.
  - MAN IN SPACE APPEARS NECESSARY FOR LIFE SCIENCE PROGRAM AND EXPANDING COMMERCIAL SPACE PROCESSING.

- CURRENT RECOMMENDATIONS
  - EARLY STS TECHNOLOGY DEMONSTRATIONS IMPORTANT FOR SPACE STATION.
    - ET PROPELLANT SCAVENGING AND IN-SPACE CRYO RELIQUIFICATION
    - AEROBRAKING TECHNIQUE
    - OPTICAL SYSTEMS ASSEMBLY/REFURBISHMENT/TEST



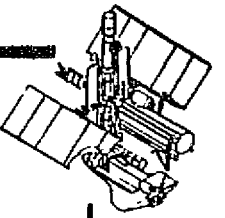
Mission Requirements

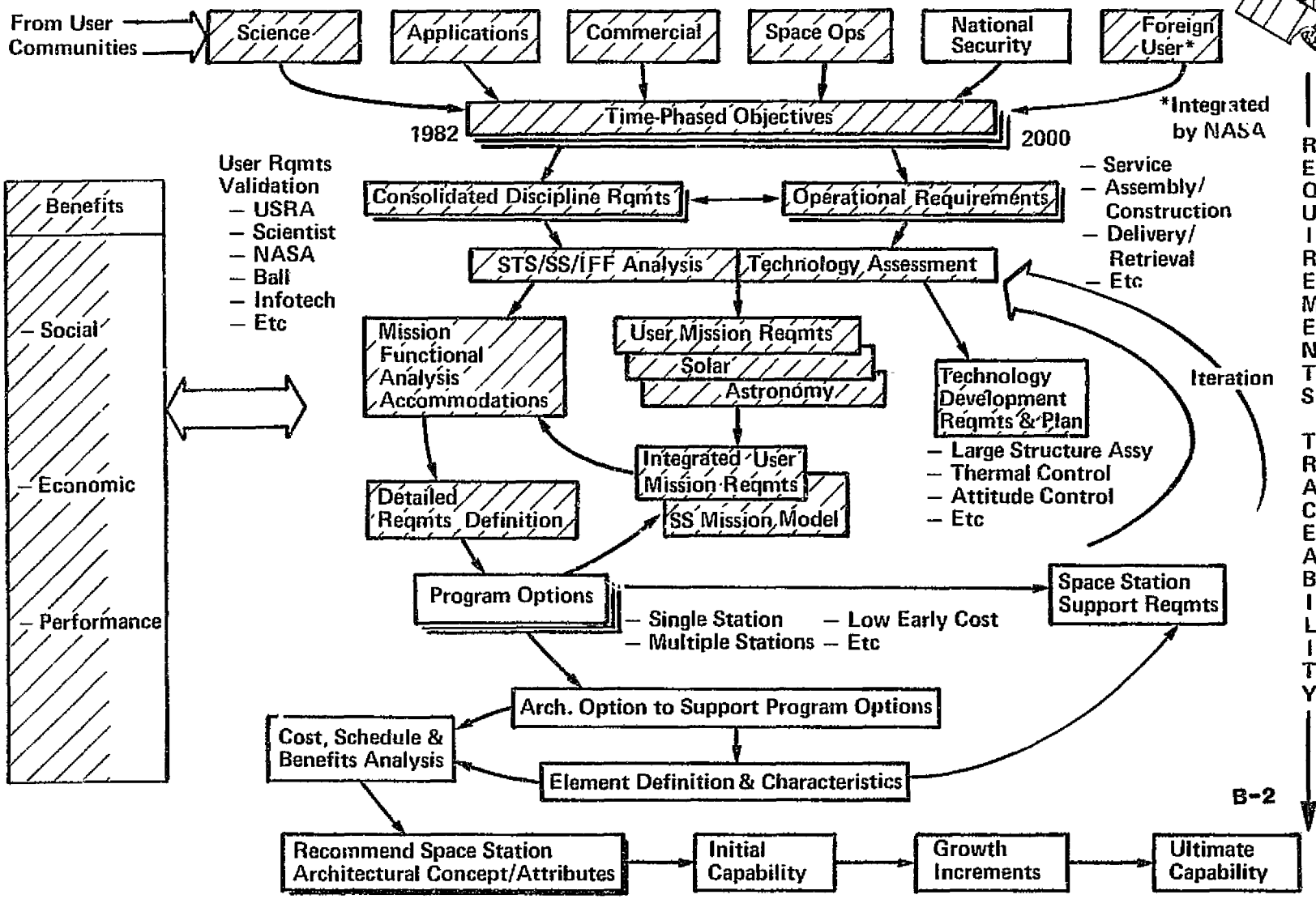
Thomas J. Sullivan

B-1

MARTIN MARIETTA

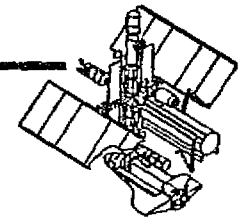
Space Station Study Flow





B-2

Objective and Scope



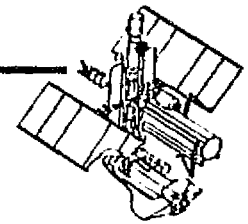
Objective

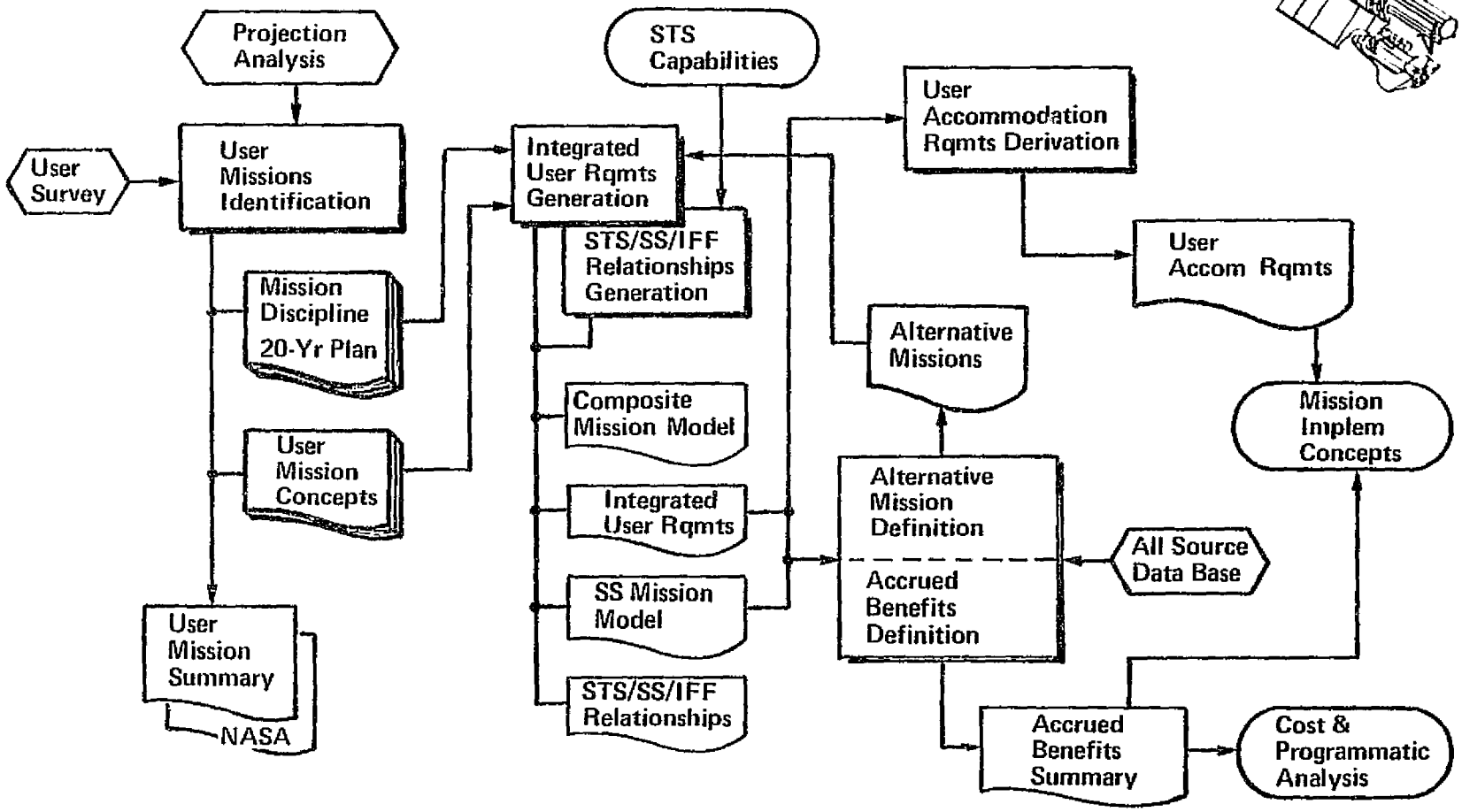
- To identify and validate user mission requirements and benefits that may be used to assess the desirability of a national space station program.

Scope

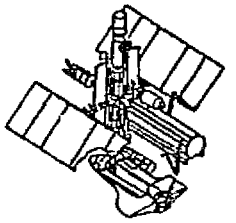
- Identify User Missions
- Develop User Mission Requirements
- Establish Requirements Relationships to STS/SS/IFF
- Define SS User Accommodation Requirements
- Determine Mission Alternatives and Accrued Benefits

Task Flow




Projection Analysis
STS Capabilities
User Survey
User Missions Identification
Integrated User Rqmts Generation
User Accommodation Rqmts Derivation
STS/SS/IFF Relationships Generation
User Accom Rqmts
Mission Discipline 20-Yr Plan
Alternative Missions
Composite Mission Model
Mission Inplem Concepts
User Mission Concepts
Alternative Mission Definition
Integrated User Rqmts
All Source Data Base
SS Mission Model
Accrued Benefits Definition
User Mission Summary
NASA
STS/SS/IFF Relationships
Accrued Benefits Summary
Cost & Programmatic Analysis

User Missions



OBJECTIVE

- TO ESTABLISH USER MISSION-LEVEL REQUIREMENTS FOR MISSIONS THAT WILL DERIVE SIGNIFICANT BENEFITS FROM A MANNED SPACE STATION FOR:
  - SCIENCE
  - APPLICATIONS
  - COMMERCIAL
  - SPACE OPERATIONS
  - U.S. NATIONAL SECURITY

APPROACH

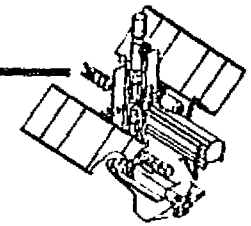
PROJECTION	SURVEY
• LITERATURE REVIEW	• USER IDENTIFICATION
• 20-YR BASELINES	• CONTACT PLAN
• USER REQMTS	• USER REQMTS

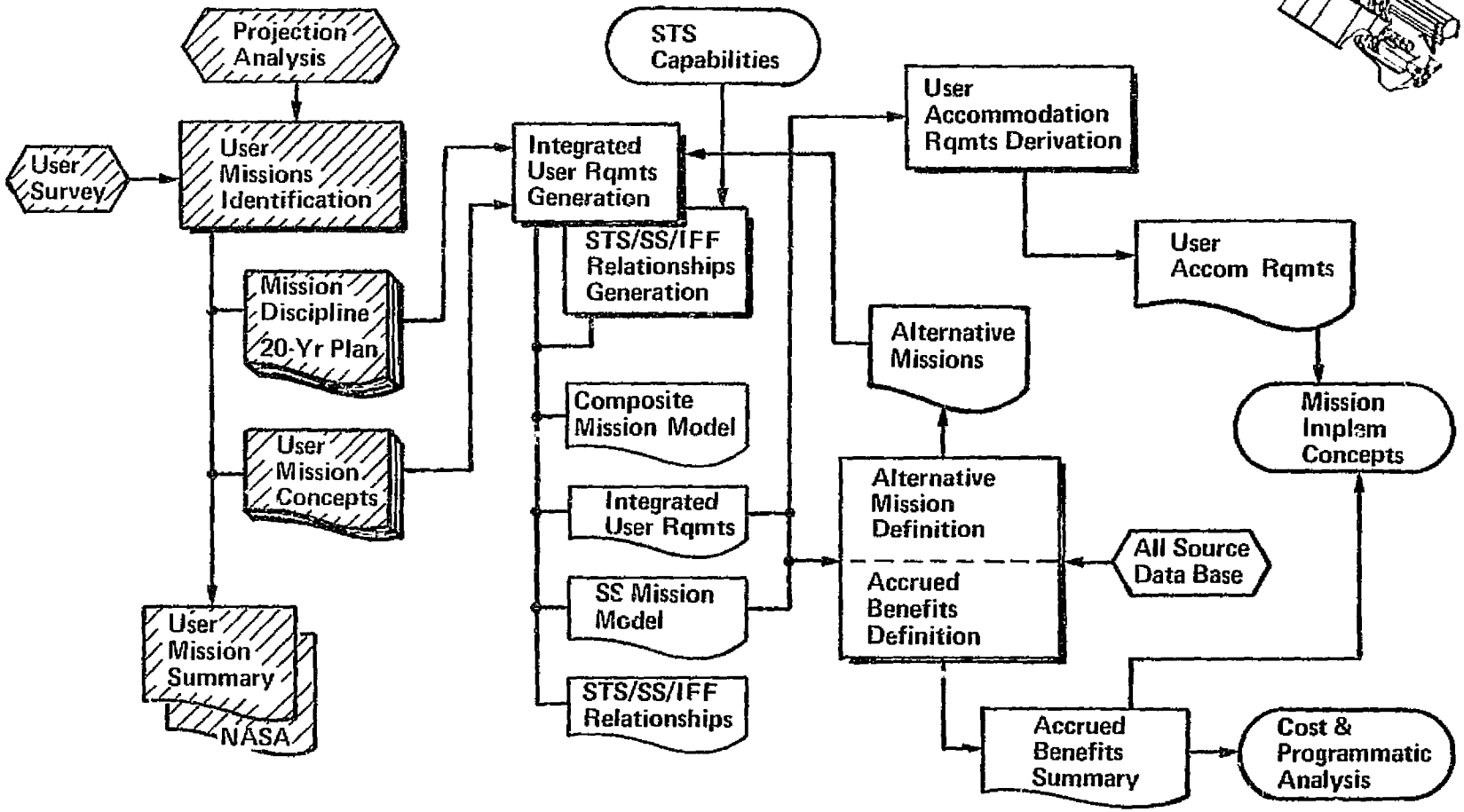
→ VALIDATION PROCESS ←

↓

20-YR PLAN AND USER REQMTS

Task Flow

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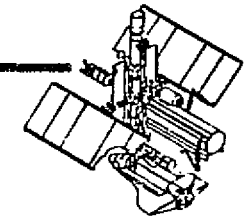
SS Mission Model
Accrued Benefits Definition
User Mission Summary
NASA
STS/SS/IFF Relationships
Accrued Benefits Summary
Cost & Programmatic Analysis

Mission Categories



SCIENCE

- S-1 PLANETARY OBSERVATION
- S-2 EARTH OBSERVATION
- S-3 SPACE PHYSICS
- S-4 ASTRONOMY
- S-5 SOLAR PHYSICS
- S-6 LIFE/BIO/MED SCIENCES
- S-7 •
  •

APPLICATION

- A-1 MATERIALS PROCESSING
- A-2 •
  •

COMMERCIAL

- C-1 SPACE PROCESSING
- C-2 COMMUNICATION SATELLITE
- C-3 •
  •

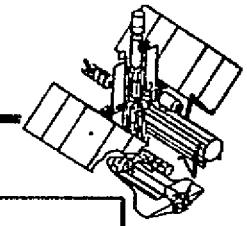
SPACE OPERATIONS

- O-1 SATELLITE SERVICING
- O-2 ASSEMBLY OF SPACE STRUCTURES
- O-3 FLUID TRANSFER/STORAGE
- O-4 OPERATING PLATFORM
- O-5 LAUNCH TRANSFER
- O-6 PROPULSION
- O-7 SPACECRAFT CONTROL
- O-8 DATA MGMT & COMMUNICATION
- O-9 ELECTRICAL
- O-10 CREW SYSTEMS
- O-11 THERMAL CONTROL
- O-12 •
  •

U. S. NATIONAL SECURITY

- D-1 EXISTING PROGRAMS
- D-2 NEW PROGRAMS
- D-3 SPACE STATION SPECIFIC APPLICATIONS
  •
  •

User Requirements Generation and Validation



NASA Data
- STS Flight Assignment Baseline
- Space Systems Technology Model
- NASA Program Plan (FY 1982-1985)
- 487 Mission Model
- 10-Yr Plan (1982-1992)
- Other Contractors Models

Martin Marietta Data
- National Mission Model
- TMS Mission Model
- DOD Mission Model

International Data

Formulate Baseline Data

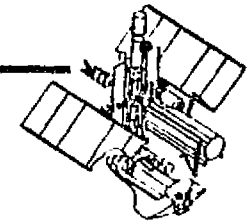
Internal Reqmts Analysis
- Classification
- 20-Yr Projection
- Integration and Synergistic Assessment

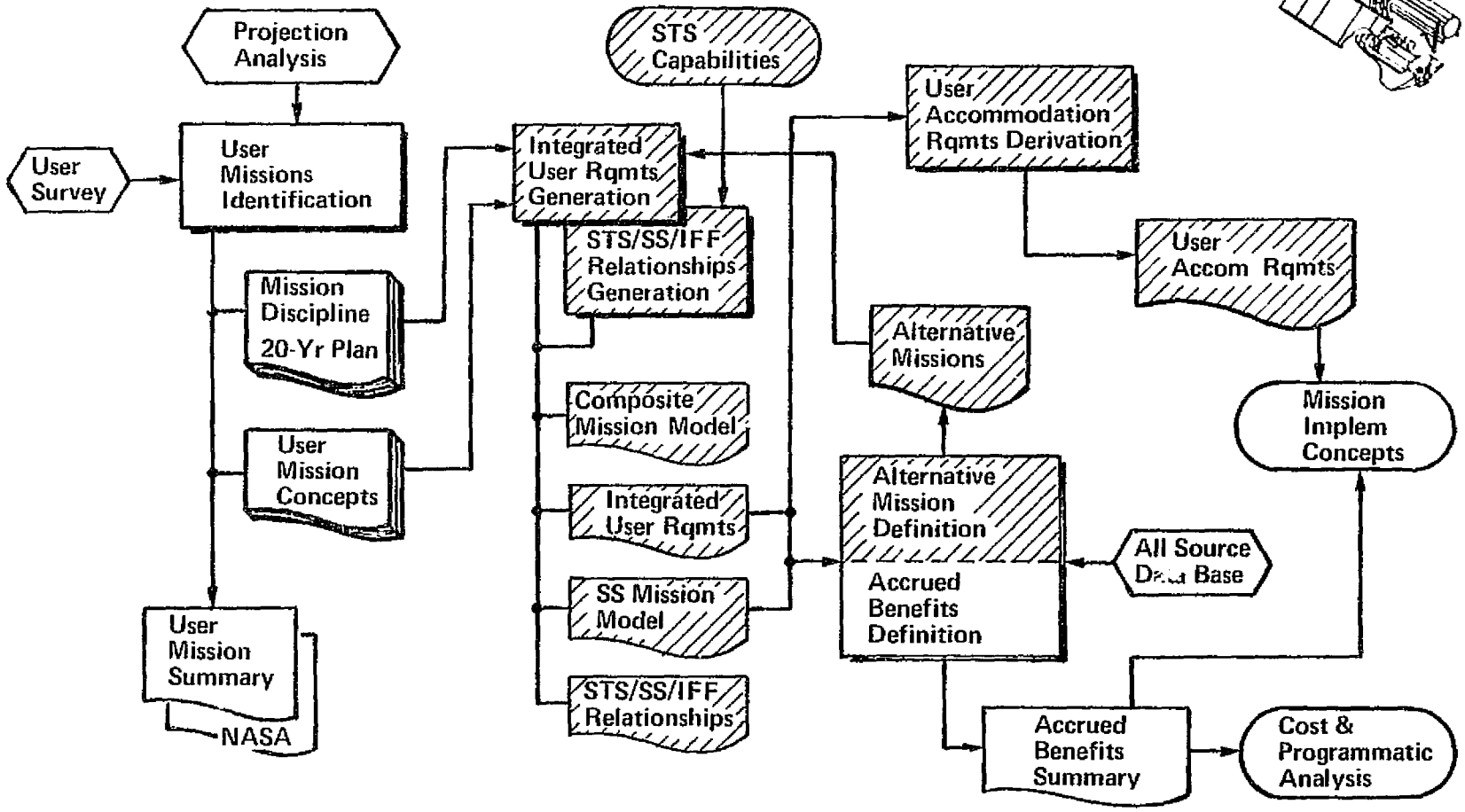
External Contacts
- USRA
- Scientists
- Commercial
- Subcontracts
- Consultants
- International

User Validated Rqmts

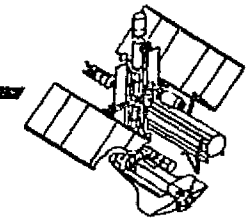
User Mission Rqmts Development Task

Task Flow





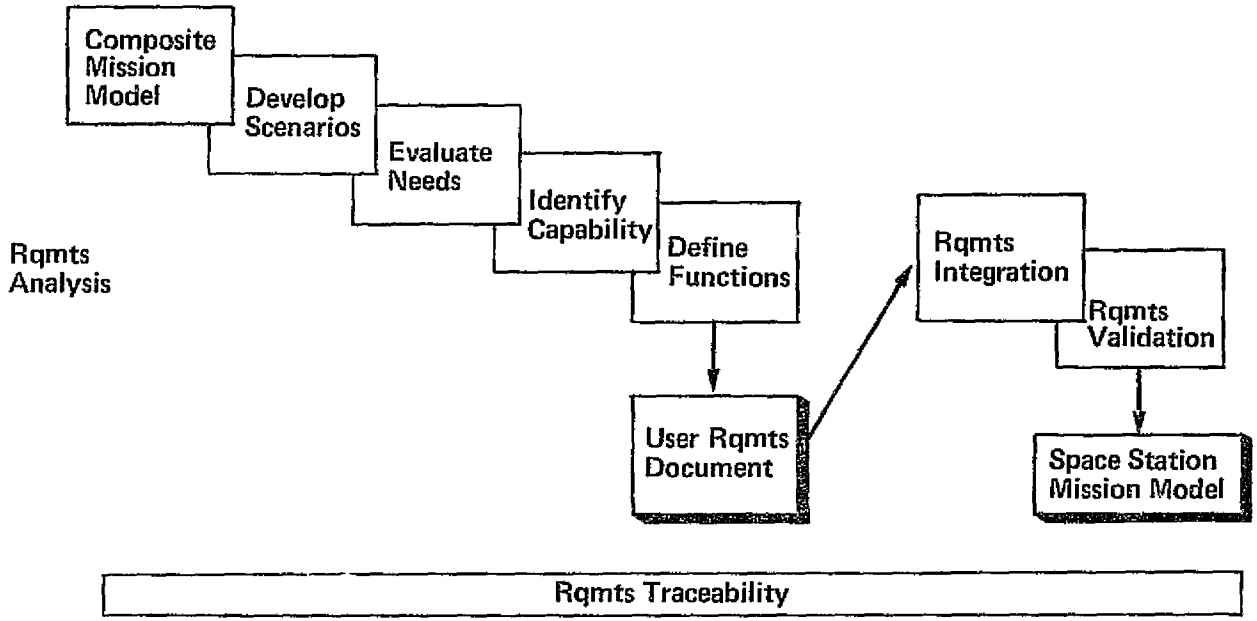
User Mission Requirements



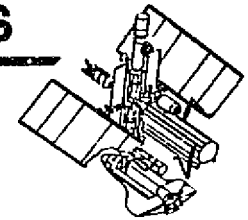
OBJECTIVES

- TO DEVELOP INTEGRATED USER REQUIREMENTS, RANKED BY UNIQUENESS OF CAPABILITY AND FUNCTION.
- TO MAINTAIN REQUIREMENTS TRACEABILITY.
- TO DEVELOP AN INTEGRATED SPACE STATION USER MISSION MODEL

APPROACH

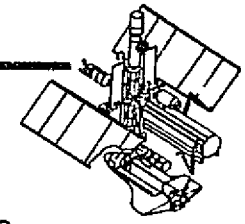


Space Station Potential Functional Capabilities



- Sortie Support
  - Assembly/Construction
    - Delivery/Retrieval
      - Servicing
        - Operations Control Center
          - Supply (Logistics)/Storage/Repair
            - Communications & Data Handling
              - Receiving
              - Relay
              - Processing/Data Compression
              - Real-Time Interface
            - Sterilization
              - Lab/Test Facility
                - Tethered Operations
                  - LOS/LON/LOD - Enhancements
                    - Safety
                      -
                      -

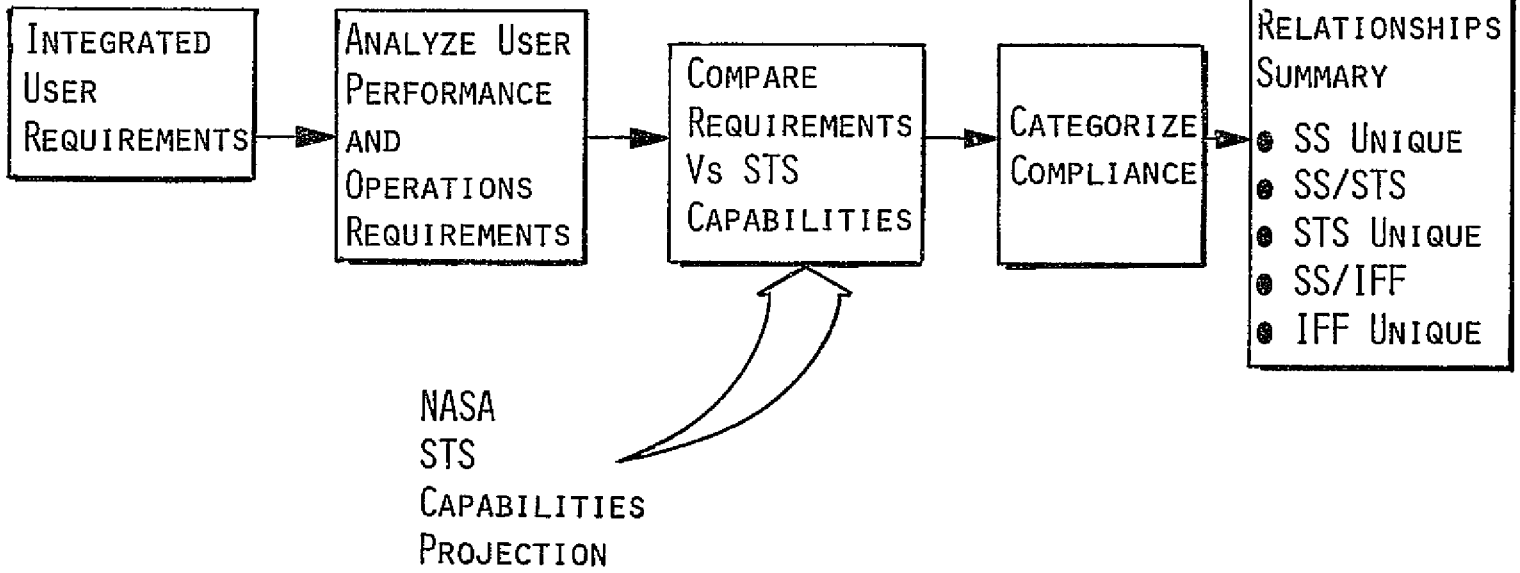
Requirements Relationship to STS



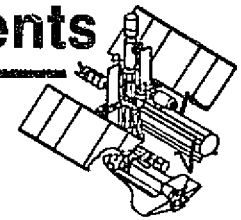
OBJECTIVE

- TO ESTABLISH THE RELATIONSHIP OF INTEGRATED USER REQUIREMENTS TO THE CURRENT STS BY ASSESSING THE CAPABILITY OF THE STS TO SATISFY MISSION REQUIREMENTS FOR USER MISSIONS.

APPROACH



Space Stations User Accommodation Requirements

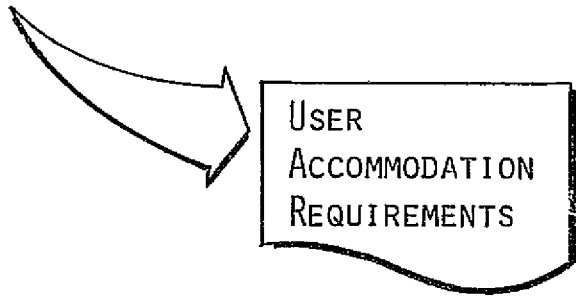


OBJECTIVE

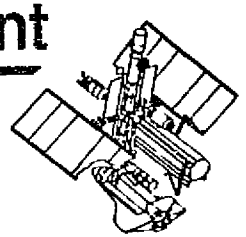
- TO ESTABLISH SPACE STATION SYSTEM CHARACTERISTICS, PERFORMANCE, AND OPERATIONAL REQUIREMENTS TO SATISFY USER MISSIONS AND PROGRAM NEEDS THROUGH THE YEAR 2000.

APPROACH

- GROUP AND TRANSLATE USER MISSION REQUIREMENTS AND NEEDS INTO SPACE STATION ACCOMMODATION REQUIREMENTS.
  - TIME ORDER CHARACTERISTICS, PERFORMANCE, AND OPERATIONAL REQUIREMENTS TO IDENTIFY TRENDS AND MAXIMIZE SPACE STATION MISSION CAPABILITIES.

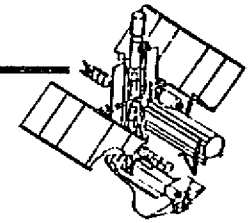


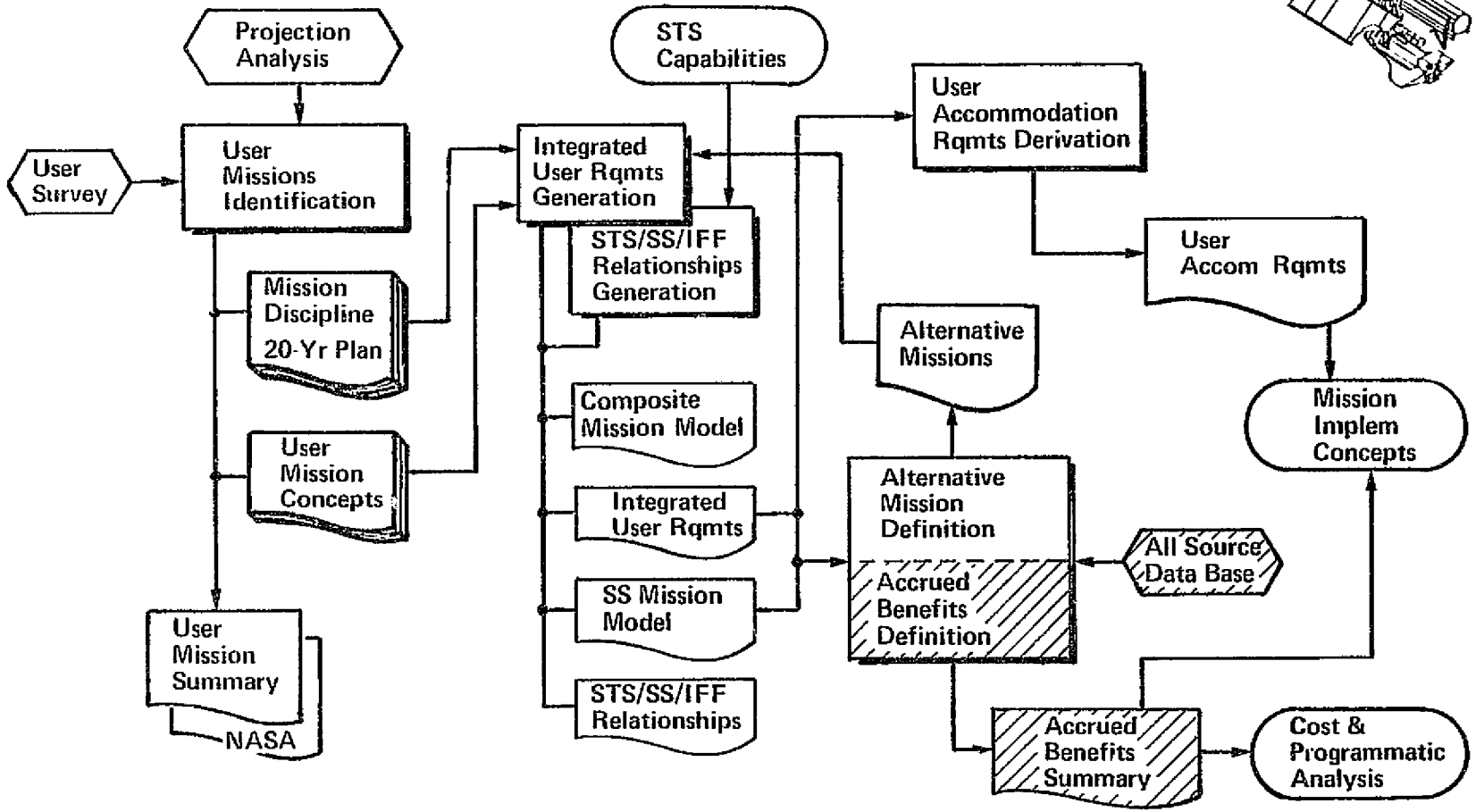
User Accommodations Requirements Document



- User Mission Requirements and Program Needs
  - User-Unique Capabilities and Functions
    - Integrated User Requirement Categories
      - Integrated User Model Needs
        - User Requirements Relationship – STS/SS/IFF
          - SS System Characteristics
            - SS Performance Requirements
              - SS Operations Requirements
                - Time-Ordered SS System Characteristics, Performance Requirements and Operations Requirements
                  - Identification of Capability Trends

Task Flow

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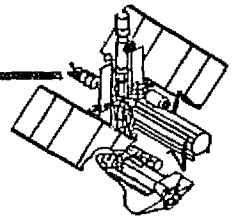
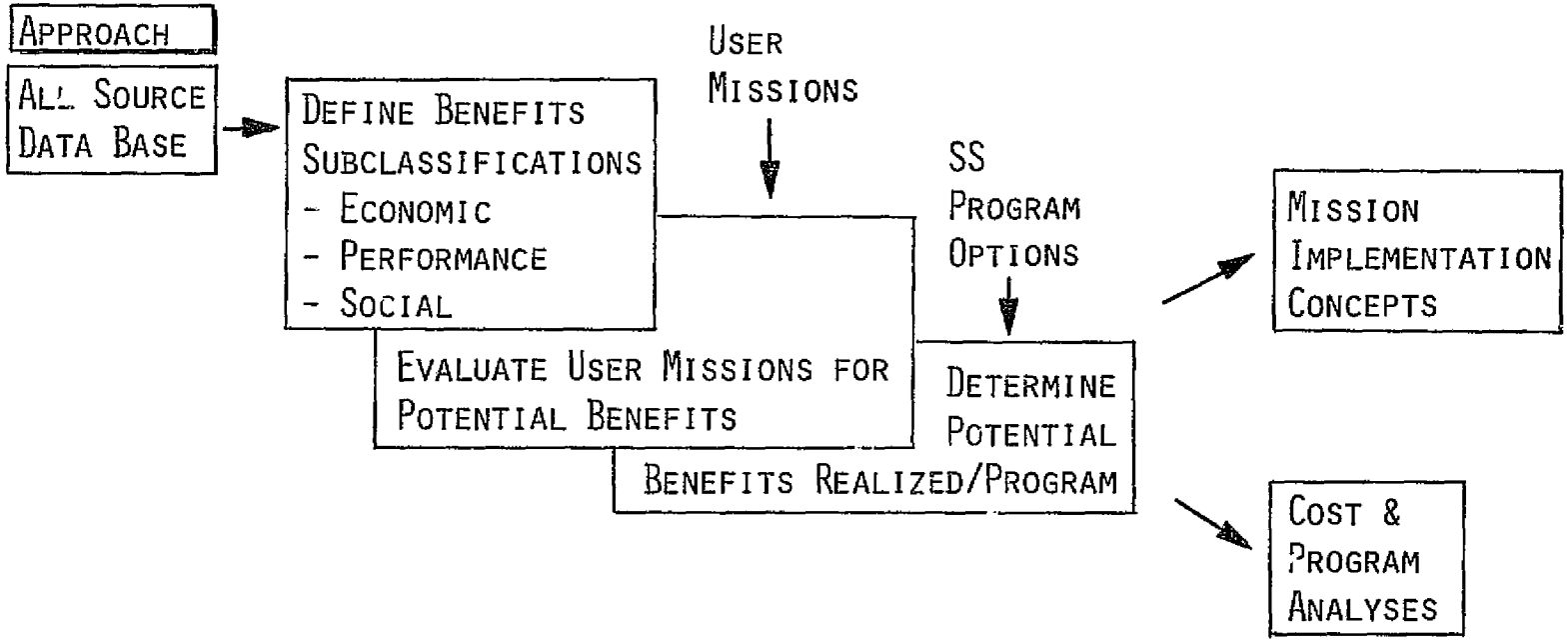
User Accommodation Rqmts Derivation
STS/SS/IFF Relationships Generation
User Accom Rqmts
Mission Discipline 20-Yr Plan
Alternative Missions
Composite Mission Model
Mission Implem Concepts
User Mission Concepts
Integrated User Rqmts
Alternative Mission Definition
All Source Data Base
SS Mission Model
Accrued Benefits Definition
User Mission Summary
NASA
STS/SS/IFF Relationships
Accrued Benefits Summary
Cost & Programmatic Analysis

Mission Alternatives and Accrued Benefits

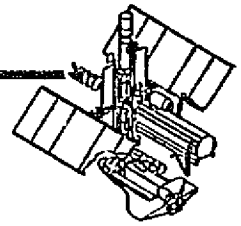


OBJECTIVE

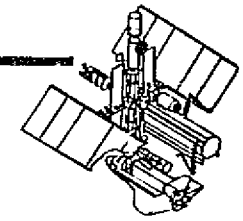
- DEFINE THE ECONOMIC, PERFORMANCE AND SOCIAL BENEFITS THAT ACCRUE FROM ALTERNATIVE APPROACHES TO MISSION ACCOMPLISHMENTS MADE POSSIBLE BY A MANNED SPACE STATION.



Agenda



SUBJECT	SPEAKER
Introduction	R. B. Demoret
Executive Summary	S. R. Schrock
Mission Requirements	T. J. Sullivan
- User Mission Requirements Development	F. J. Steputis
- Astronomy/Space Physics/Planetary	F. Bartko
- Solar Physics/Earth Observations	S. M. Pompea
- Comm./Life Sci./Mtls Proc./Commercial	W. O. Nobles
- Space Station and User Requirements Analysis	G. E. Stone
- Accrued Benefits	T. J. Sullivan
Mission Implementation Concepts	T. J. Rasser
Cost, Schedule, and Benefits Analysis	T. A. Mottinger
DOD Tasks	T. K. Sulmeisters
Adjournment	

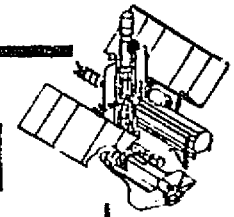


User Missions

Requirements Development

Fred Steputis

Space Station Study Flow



From User Communities

Science | Applications | Commercial | Space Ops | National Security | Foreign User*

*Integrated by NASA

1982 — Time-Phased Objectives — 2000

User Rqmts Validation
- USRA
- Scientist
- NASA
- Ball
- Infotech
- Etc

Benefits
- Social
- Economic
- Performance

Consolidated Discipline Rqmts ↔ Operational Requirements
- Service
- Assembly/ Construction
- Delivery/ Retrieval
- Etc

STS/SS/IFF Analysis | Technology Assessment

Mission Functional Analysis Accommodations

User Mission Reqmts
Solar
Astronomy

Technology Development Reqmts & Plan
- Large Structure Assy
- Thermal Control
- Attitude Control
- Etc

Iteration

Integrated User Mission Reqmts
SS Mission Model

Detailed Reqmts Definition

Program Options
- Single Station
- Multiple Stations
- Low Early Cost
- Etc

Space Station Support Reqmts

Arch. Option to Support Program Options

Cost, Schedule & Benefits Analysis

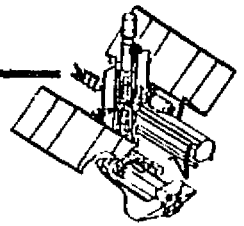
Element Definition & Characteristics

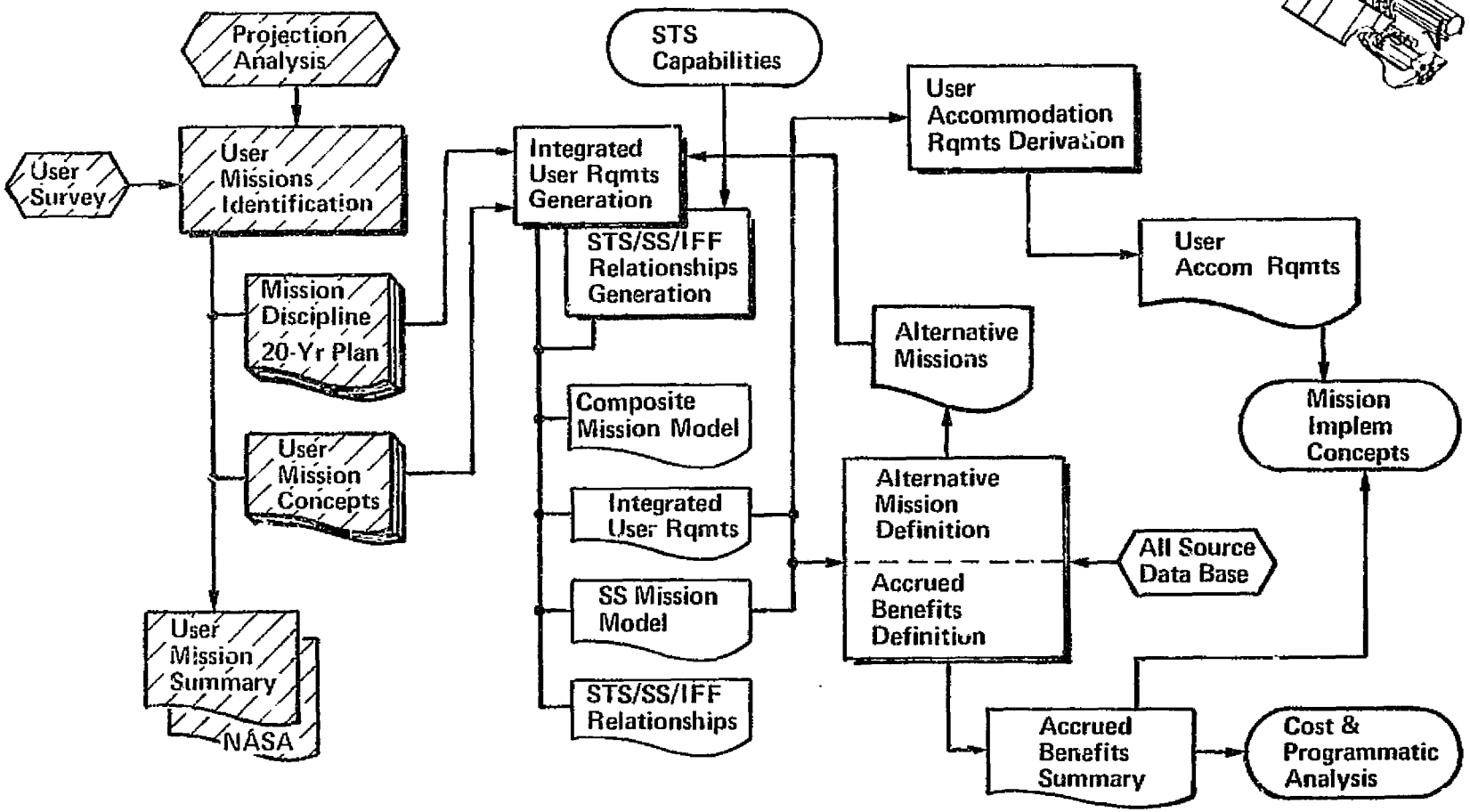
Recommend Space Station Architectural Concept/Attributes → Initial Capability → Growth Increments → Ultimate Capability

REQUIREMENTS TRACEABILITY

C-2

Task Flow




Projection Analysis
STS Capabilities
User Survey
User Missions Identification
Integrated User Rqmts Generation
User Accommodation Rqmts Derivation
STS/SS/IFF Relationships Generation
User Accom Rqmts
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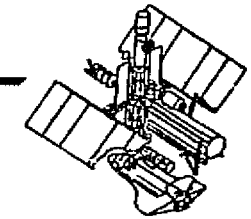
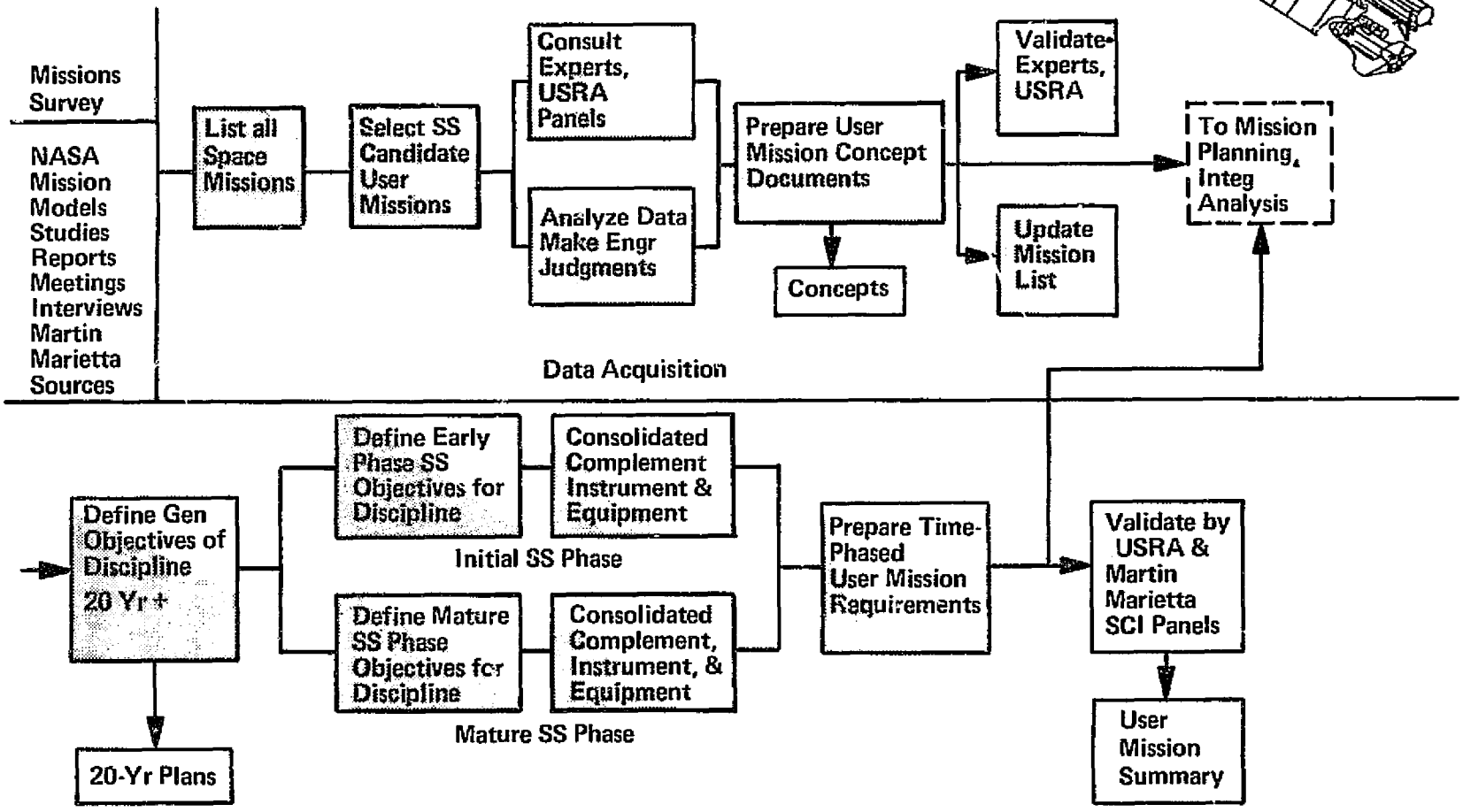
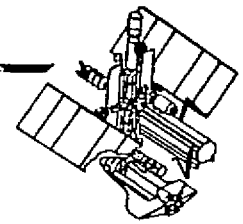
User Mission Requirements Development





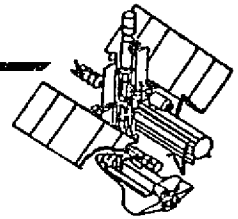
Candidate Mission Selection



20 Year Plans and Objectives for SS Established

- Missions Considered - Composite Mission Model Candidates Incorporated into Overall Planning
  - Astronomy 37
  - Space Physics 6
  - Planetary Exploration 7
  - Solar Physics 10
  - Earth Observations 55
  - Life Sciences 13
  - Communications 88
  - Material Processing 22
  - Operations 54
- Additional Missions and Discipline Overall Objectives Established
  - Survey of Data
  - Panel Discussions
  - Personal Interviews
  - Telephone Interviews
  - Consultants
- Candidate Mission Complement Selected
  - Implement Objectives
  - Non-Redundant
  - Applicability in Space Station Era
  - Potential Utilization of SS Capabilities

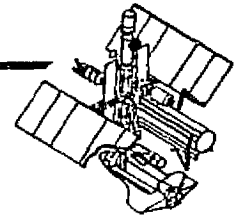
Contacts Made



STATUS AND ACCOMPLISHMENTS

SCIENCE (INCLUDES ALL EARTH OBSERVATION)	PERSONAL INTERVIEWS CONDUCTED	95
	TELEPHONE INTERVIEWS CONDUCTED	50
	CONTACTS REMAINING	97
APPLICATIONS (COMMUNICATIONS MATERIAL PROCESSING)	PERSONAL INTERVIEWS CONDUCTED	14
	TELEPHONE INTERVIEWS CONDUCTED	16
	CONTACTS REMAINING	31
OPERATIONS	PERSONAL INTERVIEWS CONDUCTED	3
	TELEPNONE INTERVIEWS CONDUCTED	33
	CONTACTS REMAINING	16
USER MISSION CONCEPTS DOCUMENTS RELEASED		40

USRA Panels



USRA Panels Convened - Jack Sevier, USRA Coordinator

Space Physics - October 27, 1982
- Dr. Peter Banks - Stanford
- Dr. Milford H. Davis - USRA
- Dr. John Gille - NCAR

Atmospheric Science - October 28, 1982
- Dr. Verner Suomi - Univ of Wisc
- Dr. Thomas Von der Haar - Colo State Univ
- Dr. William Smith - NOAA

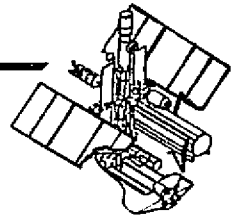
Atmospheric Science - November 2, 1982
- Dr. Thomas Von der Haar - Colo State Univ
- Dr. Milford H. Davis - USRA

Astrophysics - November 3, 1982
- Dr. Robert C. Haymes - Rice Univ
- Dr. Frank J. Kerr - Univ of Maryland
- Dr. Melville Ulmer - Northwestern Univ

Life Sciences - November 5, 1982
- Mr. Richard Johnston - Texas Med Center
- Dr. Carter Alexander - Brooks AFB

Remote Sensing - November 9, 1982
- Dr. Anne B. Kahle - JPL
- Dr. Richard W. Newton - Texas A&M
- Dr. William Kowalik - Chevron Oil Research

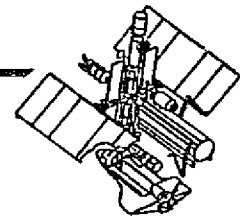
User Mission Concept Document



SUBJECTS COVERED - (USER MISSION DATA SHEETS)

- PROGRAM DATA
  - TITLE
  - USER ORGANIZATION
  - PRINCIPAL CONTACT
  - ADDRESS
  - PROGRAM OBJECTIVES
  - PROJECTED NEEDS, EVOLUTION
  - DEVELOPMENT STATUS
  - SPONSORSHIP
- SYSTEMS INTEGRATION
  - OPERATIONS
  - MANS ROLE
  - SHUTTLE/OTV
    - RETURN, RESUPPLY, RETRIEVAL
  - EQUIPMENT DESCRIPTION
  - MOUNTING PROVISIONS
  - ORBITAL FLIGHT
  - SUBSYSTEMS SUPPORT
    - ELECTRICAL POWER
    - THERMAL CONTROL
    - DATA MANAGEMENT
    - COMMAND & CONTROL
    - POINTING, STABILITY
  - HAZARDS AND PRECAUTIONS
- SPECIAL DATA
  - SPACE STATION SPECIAL ADVANTAGES
  - BENEFITS
    - SCIENTIFIC
    - COMMERCIAL
    - POLITICAL
    - SOCIAL
    - ECONOMIC
  - REFERENCE DATA
  - KEY PERSONNEL

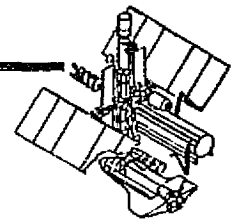
Concept Development



GROUND RULES

- TOP LEVEL TIME PHASED AND PRIORITIZED OBJECTIVES FOR DISCIPLINE.
- CONCEPTS TO IMPLEMENT OBJECTIVES.
- CONCEPTS WITHOUT REGARD TO CURRENT PROGRAM STATUS OR FUNDING.
- CONCEPTS WITHOUT PRECONCEPTIONS OF SS CAPABILITIES.
- SS INCLUSIVE OF ADJUNCT PLATFORMS, AND SATELLITES.
- CONCEPTS TAKE ADVANTAGE OF THE SS SPECIAL CAPABILITIES.
  - LONG DURATION
  - MAN AS OBSERVER OPERATOR, REPAIRMAN
  - RESUPPLY AND RETURN OF SAMPLES OR COMPONENTS
  - RETRIEVAL, REPAIR & REFURBISHMENT
  - SPECIALIZED FACILITIES AND EQUIPMENT
  - ASSEMBLY, CHECKOUT, ALIGNMENT, CALIBRATION ON-ORBIT
  - LAUNCH TO OTHER TRAJECTORIES
  - LARGE WEIGHTS & VOLUMES

User Missions



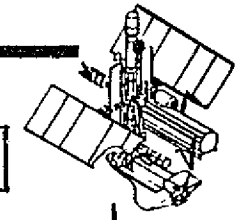
Astronomy

Space Physics

Planetary Studies

F. Bartko

Space Station Study Flow



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1982 — Time-Phased Objectives — 2000

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- Scientist
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Consolidated Discipline Rqmts ⟷ Operational Requirements

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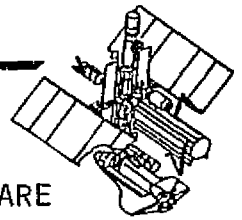
REQUIREMENTS TRACEABILITY

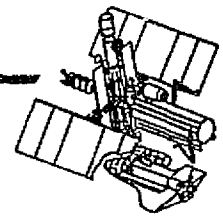
D-2

Introduction



- USER MISSIONS FOR SPACE ASTRONMOMY, SPACE PHYSICS, AND PLANETARY STUDIES ARE DESCRIBED (ACKNOWLEDGE BASD - M. BOTTEMA, D. SCHNEIBLE, R. SCOTT).
- ESSENCE OF OUR APPROACH IS DEVELOPMENT OF A 20-YEAR PROJECTION.
- PROJECTION RELIES HEAVILY ON NAS REPORTS.
  - BUILT-IN VALIDATION
- PROJECTION IS BASED ON SOUND SCIENTIFIC STRATEGY THAT PROVIDES TIME-PHASED DEVELOPMENT (EXPLORATORY/SURVEY ⟶ DETAILED STUDY/MATURE OBSERVATORY ⟶ SPECIALIZED TECHNIQUES).

Astronomy Contact Plan



Data Sources

- National Academy of Sciences, Astronomy Survey Committee: Astronomy and Astrophysics for the 1980s, 1982.
- NASA: Space Systems Technology Model, Vol 1,2,3 Sept 1981.
- Technology for Space Astrophysics: The Next 30 Years Conference Proceedings, (AIAA, SPIE, OSA), Danbury, Ct Oct 1982
- National Academy of Sciences, Committee on Space Astronomy and Astrophysics: A Strategy for Space Astronomy and Astrophysics for the 1980s, 1979.

Contacts Made

Organization	Individual
Univ of Texas	H. Smith
NASA/GSFC	S. Holt
Univ of Colo/JILA	R. McCray
Univ of Maryland	F. Kerr
Rice Univ	R. Haymes
Northwestern Univ	S. Ulmer
MIT	B. Burke
NRL	H. Gursky

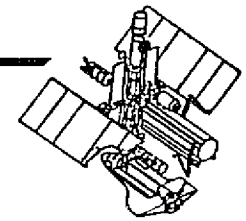
Contacts Planned

Organization	
Harvard/SAO	USCD
Princeton	UCB
MIT	CIT
UCSD	NASA/GSFC
Univ of Texas	STSI
Univ of Wyoming	
JHU	
Univ of Arizona	

Validation

Use of NAS reports and advisors constitutes initial validation.

Astronomy

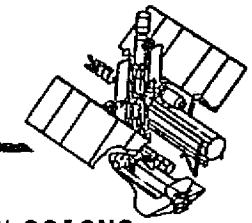


Objective

- Understand the birth of matter in the origin of the universe and the development of life in the universe.

Categories	Key Problems
• Cosmology - Galaxies and the Universe	• What is the large-scale structure/ geometry of the universe? • What is the nature and source of relativistic cosmic jets? • How do galaxies evolve and what is the nature of the hidden mass? • What powers the active galactic nuclei and quasars?
• Stellar Evolution	• How do stars and planets form, and what is the relationship of star formation to molecular/dust clouds?

Astronomy (Concl)



- What is the role of supernovae explosions in producing collapsed objects, cosmic rays, and heavy element synthesis?
- What causes activity (disturbances) on the surface of the sun and stars?
- Do extrasolar planets exist?

- Origin of Planets, Life, Intelligence

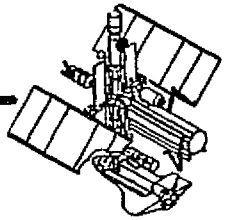
Elements

- Radio/microwave
- IR/Submillimeter
- Optical/UV/EUV
- X-Ray
- Gamma Ray
- Cosmic Rays
- Relativity

Objectives

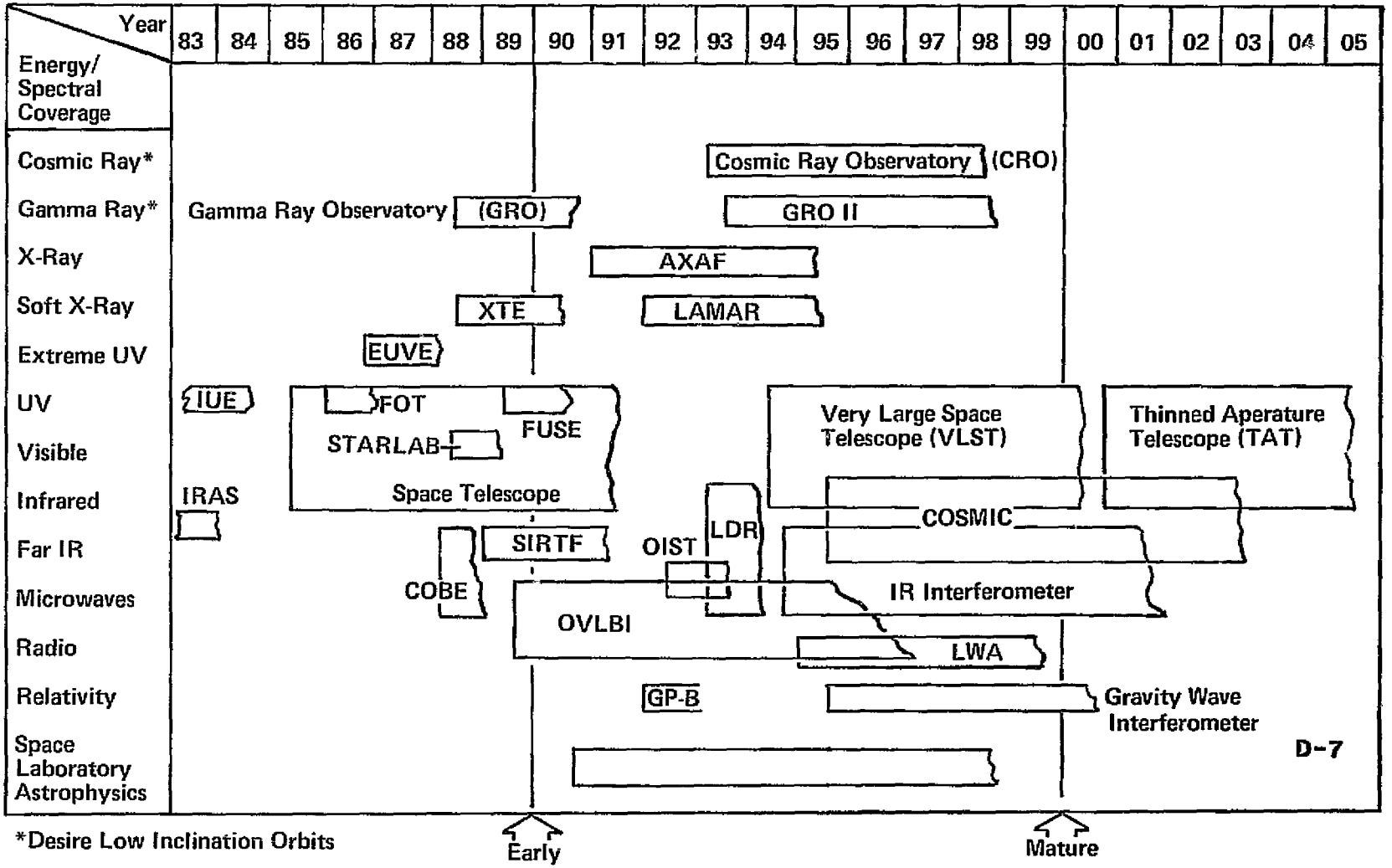
- Apply increased spectral, angular, and time resolution to major scientific questions (10 to 100 times better)
- Apply broad spectrum coverage
- Apply new techniques

Astronomy Mission Sequence



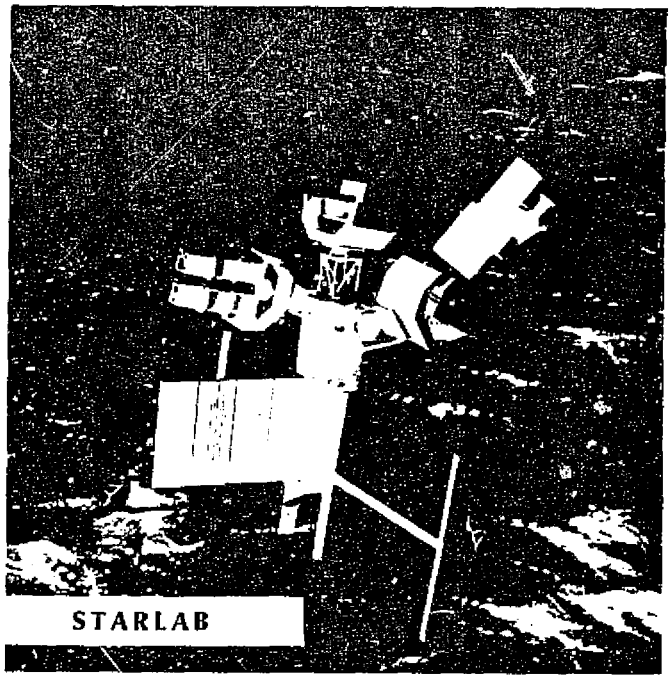
Emphasis on Broad-Spectrum Coverage

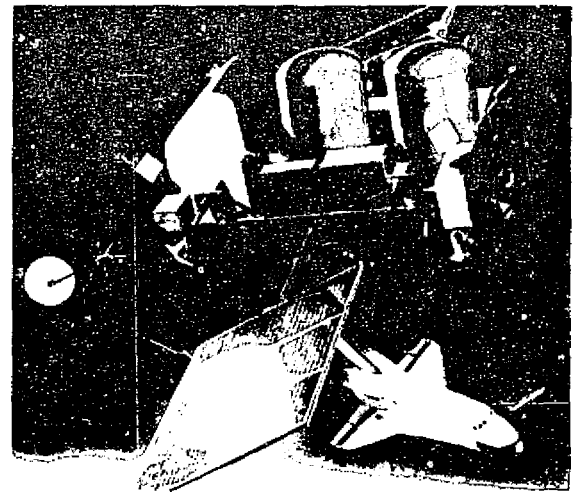
Illustrates Evolution to Next Generation Set of Requirements

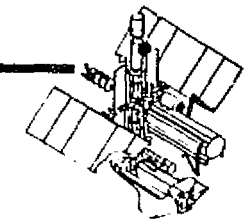


*Desire Low Inclination Orbits

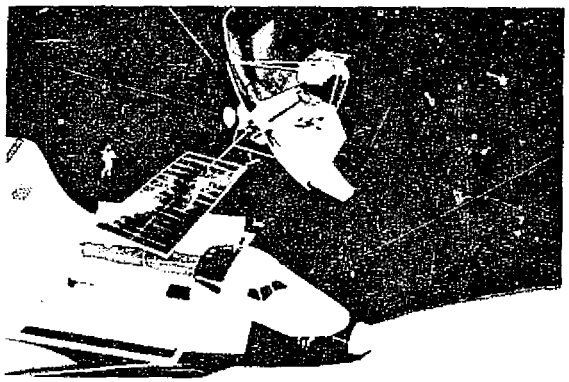
Astronomy – Early Concepts



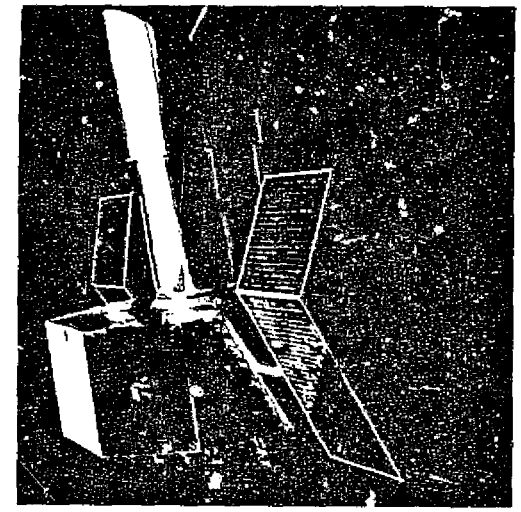




The Gamma Ray Observatory (GRO) will investigate compact sources and cosmic background at energies from 0.05 to 50 MeV.



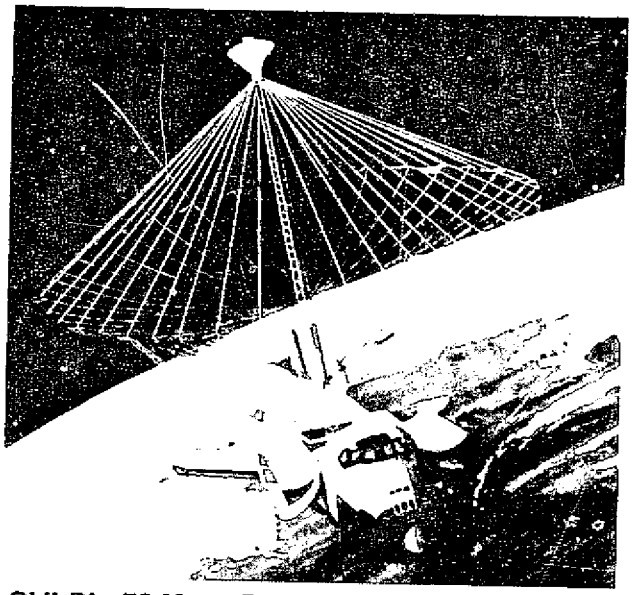
Large Deployable Reflector will perform infrared and millimeter-wave astronomy.



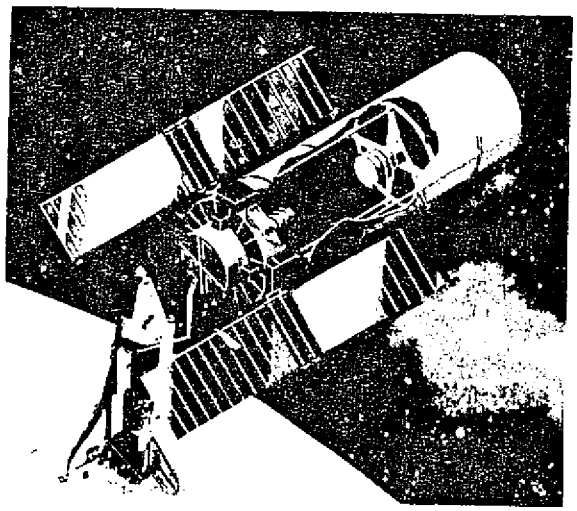
D-8

MARTIN MARIETTA

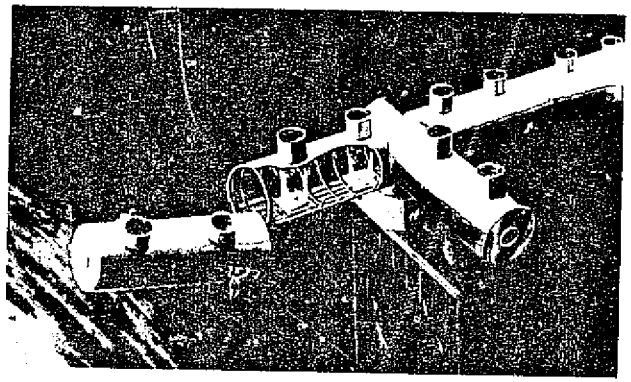
Astronomy – Mature Concepts



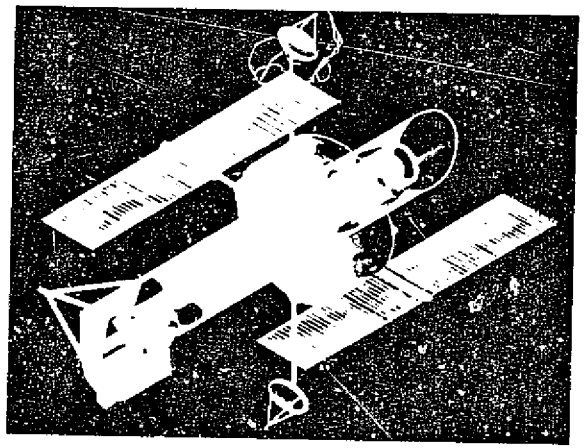
OVLBI - 50 Meter Deployable Antenna



Very Large Space Telescope (VLST) concept involves transforming the modified interstage section of the Shuttle External Tank into a telescope spacecraft.

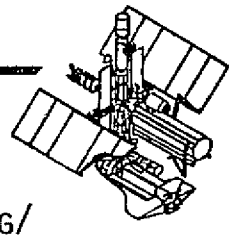


The COSMIC two-dimensional coherent array of optical telescopes is capable to resolve starspots on nearby stars.



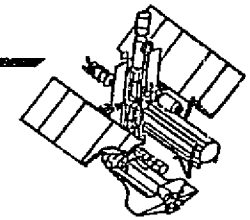
Advance X-Ray Astrophysics Facility (AXAF)

Consolidated Astronomy Requirements



- Major Operational Capabilities
  - Early Phase
    - Deployment/retrieval, servicing/maintenance/repair
    - Instrument changeout/replacement of consummables
  - Mature Phase
    - Construction/assembly; optical test & checkout
- Technology Development Areas
  - Advanced optical control techniques (active maintenance of accurate baselines, alignments, and phasing; optical beam steering/synthesis techniques)
  - Spacebased optical monitoring and testing techniques and tools
  - Large-scale stable metering structures
  - Two-dimensional, high-efficiency detector arrays
  - Onorbit Calibration Facilities
  - Consummable replenishment techniques (cryogens. gases. detectors)
  - Pointing/stability and/or image motion compensation systems to accommodate angular resolution of 10^{-4} arc sec

Space Physics Contact Plan



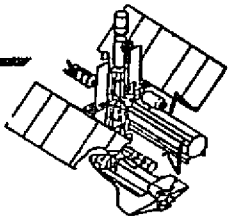
Contacts Made

Organization	Individual
MSFC	C. Chappel
	E. Hildner
	D. Reasoner
	J. Green
UCSD	R. Canfield
Stanford Univ	P. Banks
Univ of Iowa	S. Shawhan
NCAR	J. Gille
Colo State Univ	T. VonderHaar
USRA	M. Davis

Contacts Planned

Organization
Center For Astrophysics
MSFC
GSFC
JSC
APL
JPL
NCAR
HAO
Univ Of Texas, Dallas
Univ Of Wisconsin
UCLA
MIT
Univ Of Colorado
Univ Of Alaska
Univ Of California, Berkeley
Univ Of Illinois
Univ Of Michigan
Utah State Univ

Space Physics



Goal

To understand the fundamental physical processes affecting the terrestrial environment and their relation to universal processes.

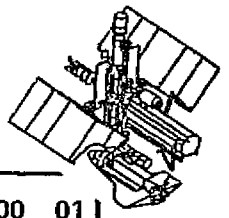
Approach

- General Plasma Interactions (Wave-Particle and Wave-Wave Interactions)
- Solar Wind-Magnetospheric Interactions
- Global and Regional Climatology Prediction and Long-Term Weather Forecasting

Major Elements	Key Objectives
• Space Plasma Physics	• Characterize Solar System Plasmas • Plasma Interactions
• Solar Terrestrial Physics	• Solar Variability Effects • Space Chemistry • Remote Magnetospheric Diagnostics • Wave-Particle Processes • Magnetosphere-Ionsphere Mass Transport • Global Electric Circuits • Upper Atmospheric Dynamics • Middle Atmospheric Turbidity • Middle Atmospheric Chemistry and Energics • Lower Atmospheric Turbidity • Planetary Atmospheric Waves

Space Physics Mission Sequence

Emphasizes Long-Term, Coordinated Measurements



Key Objectives \ Year	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01
Basic Space Physics																			
Space Plasma - Other Planets																			
Remote Magnetospheric Diagnostics																			
Space Chemistry																			
Large Structure/Plasma Interaction Effects																			
Solar Terrestrial Physics																			
Solar Variability Effects																			
Wave-Particle Processes																			
Magnetosphere - Ionosphere Interaction																			
Global Electric Circuit																			
Upper Atmosphere Dynamics																			
Middle Atmosphere Chemistry and Energetics																			
Lower Atmospheric Turbidity																			
Planetary Atmospheric Waves																			
Pre-STO Experiments & Instrument Dev																			

Very Large Radar

Initial STO

Subsatellite Facility

Plasma Turbulence Explorer

Open

Advanced Interplanetary Explorer

Chemical Release Module Facility

AMPTE

Advanced STO (Polar or Very High Inclination)

UARS

Geosynchronous STO (GEO-STO)

Initial STO (57° at 400 km)

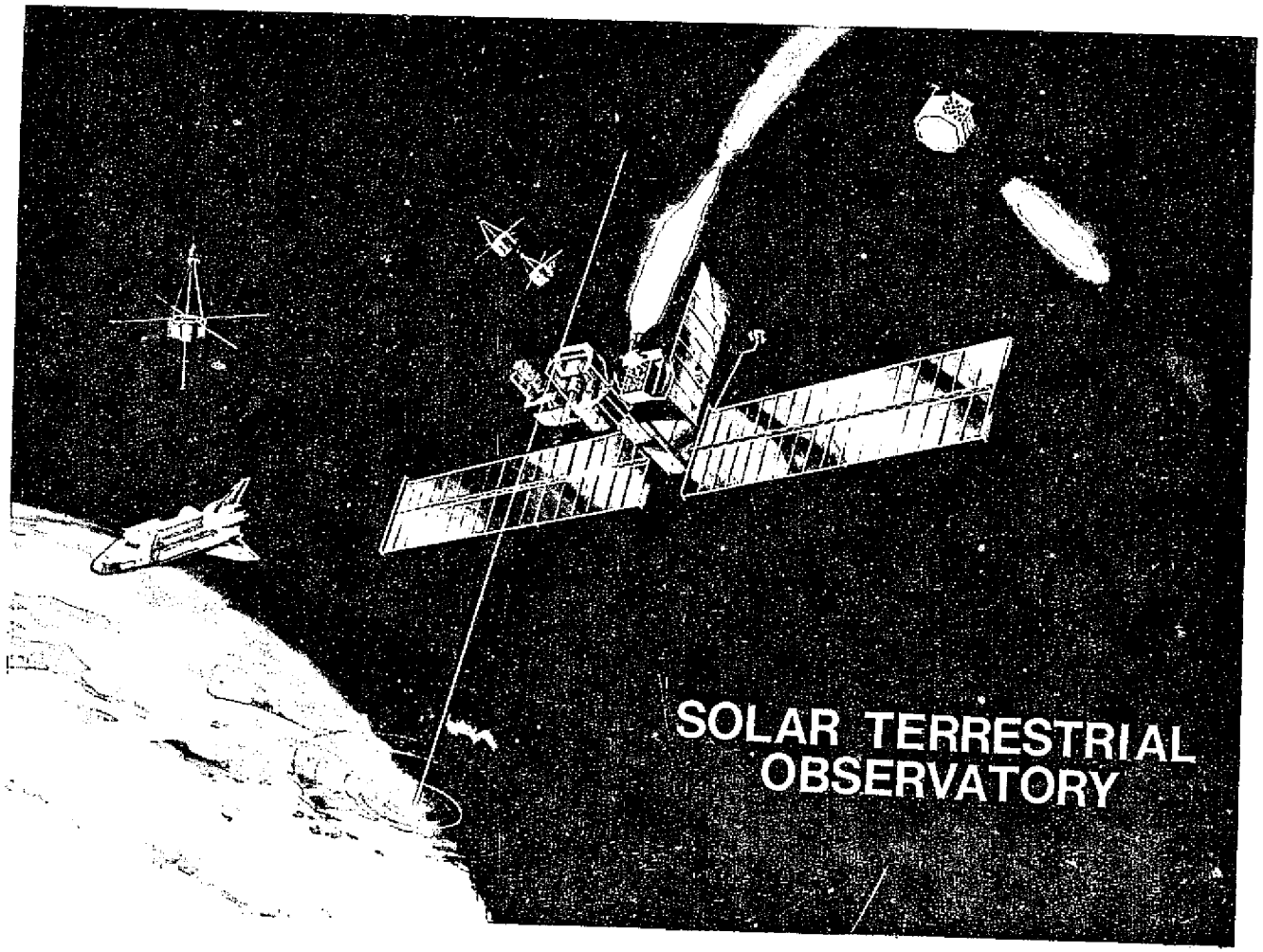
Space Lab/Shuttle Missions

Early

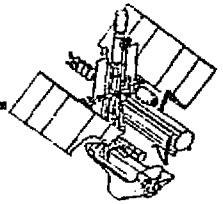
Mature

D-13

Space Physics–Solar Terrestrial Observatory



Consolidated Space Physics Requirements

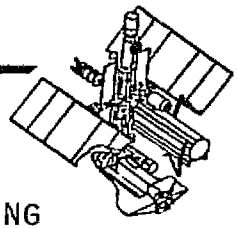


Emphasis on Orchestrated Measurements

Instrumentation Complement	
Initial STO Complement	Ultimate STO Complement[4]
Total Solar Irradiance Monitor[1]	X-Ray Irradiance Monitor[1]
UV Irradiance Monitor[1]	EUV Irradiance Monitor[1]
Soft X-ray Telescope[1]	XUV Doppler Spectroheliograph[1]
White Light Coronagraph[1]	Hard X-ray Spectrometer[1]
Resonance Line Coronagraph[1]	EUV Spectograph[1]
Chemical Release Module[3]	Radio Spectrograph[1]
Particle Injector	Coherent Scatter Radar
Plasma Wave Injector	Plasma Wave Injector
Low-Light-Level Television	Particle Injector
X-Ray Telescope	Chemical Release Module
Lidar[2]	Tethered Particles and Fields Probe
Radiation Balance Monitor[2]	Lidar[2]
IR Absorption or Emission Spectrometer[2]	Upper Atmospheric Temperature Sounder[2]
UV and Visible Spectrometer[2]	Upper Atmospheric Wind Sensor[2]
Upper Atmospheric Temperature Sounder[2]	IR Absorption or Emission Spectrometer[2]
Upper Atmospheric Wind Sensor[2]	Lightning Mapper[2]
Subsatellite Facility[3]	Very Large Aperture Radar
Ampte[3]	

Notes:
1. In concert with solar physics objectives and requirements.
2. In concert with earth observations, objectives, and requirements.
3. Supported free-flyer.
4. All initial complements not explicitly listed are also included.

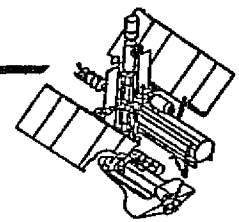
Consolidated Space Physics Requirements



- Major Capabilities
  - Need to understand proximate plasma and plasma effects monitoring during STO onorbit assembly
  - Very long-duration STO missions (solar cycle timeframe, instrument calibration)
  - Complementary interdisciplinary measurements required
  - Numerous subsatellites free-flying support requirements and servicing (maintenance, repair, changeout)
  - Onorbit data processing and reduction (central coordination facility)
  - Manned STO operation a highly desirable option (response to episodic events, instrumentation monitoring/servicing, construction/assembly, resupply, trained observer/experimenter/engineer, indepth upgrade refurbishment, modification)

- Technology Needed
  - Construct and assemble large aperture radar/antenna
  - Data management for coordinated measurements and real-time

Planetary Contact Plan



Data Sources

- National Space Club Conference Proceedings, June 1982
- J. Moore: "Effective Planetary Exploration at Low Cost," Astronautics and Aeronautics, October 1982

Contacts Completed

Organization	Individual
JPL	M. Neugebauer
	J. French

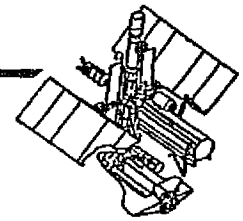
Contacts Planned

Organization
JPL (Specific Mission Data)
SAI (Specific Mission Data)
ARC (Specific Mission Data)

Validation

- SSEC Data-Validation Bulletin
- USRA/MM Consultants

Planetary Missions



Goal

To understand the nature and evolution of the solar system.

Approach

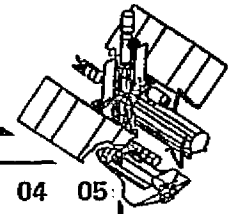
Key Objectives

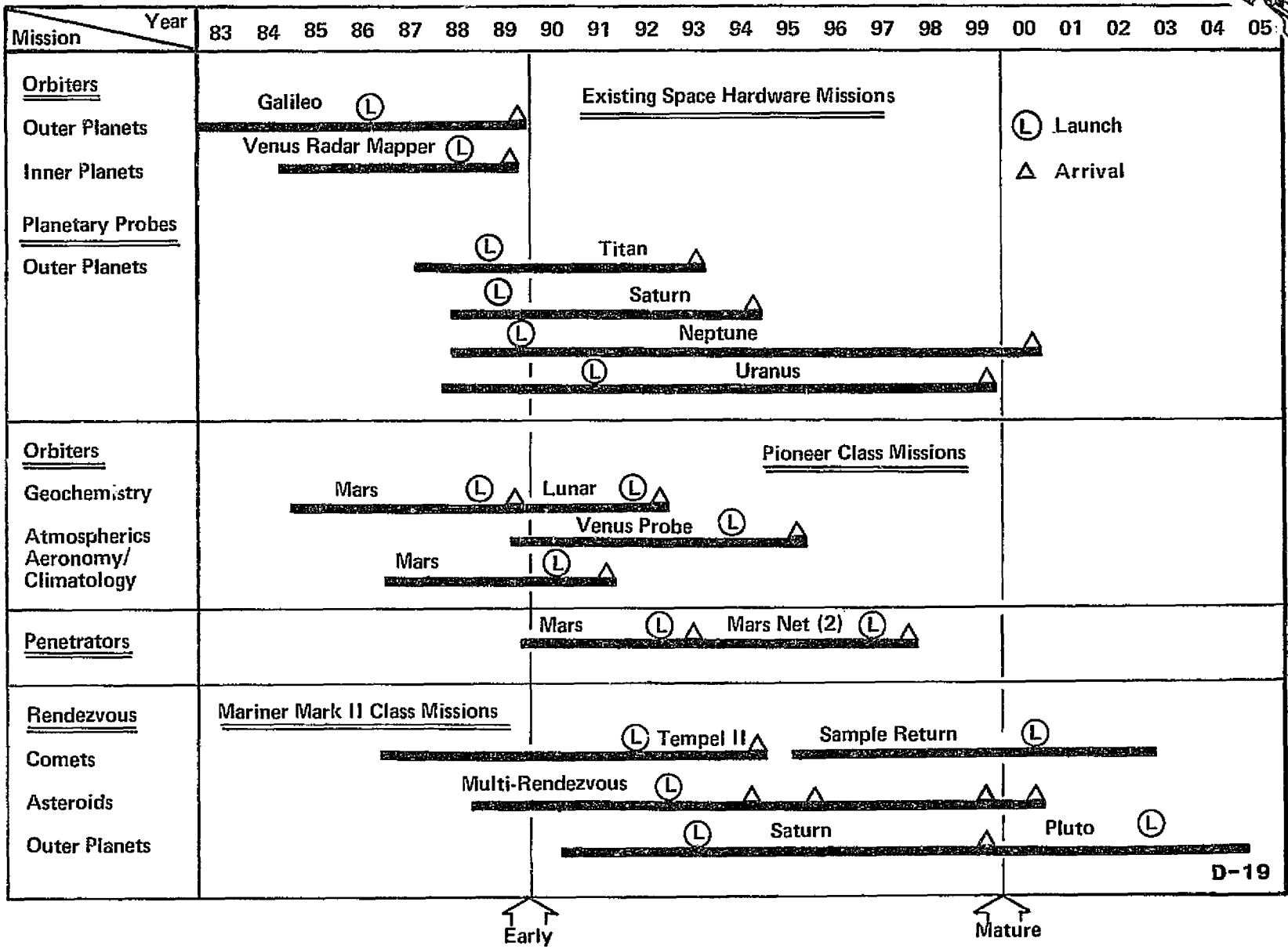
- Use broadband instruments to identify major characteristic.
- Global-scale characterization of physical state and properties with focus-defined reconnaissance.
- Indepth studies of specific, crucial scientific issues derived from exploration phase.
- Use of needed resources.

Major Elements

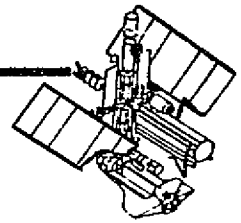
- Phase I - Initial Reconnaissance
  - Earth Observation
  - Flyby S/C
- Phase II - Exploratory
  - Orbiting S/C
  - Entry Probes
  - Landers
- Phase III - Intensive Study
  - Low-Altitude Orbiters
  - Sophisticated Probes/Landers
  - Sample Return
- Phase IV - Use/Exploitation
  - Habitable Bases
  - Remote

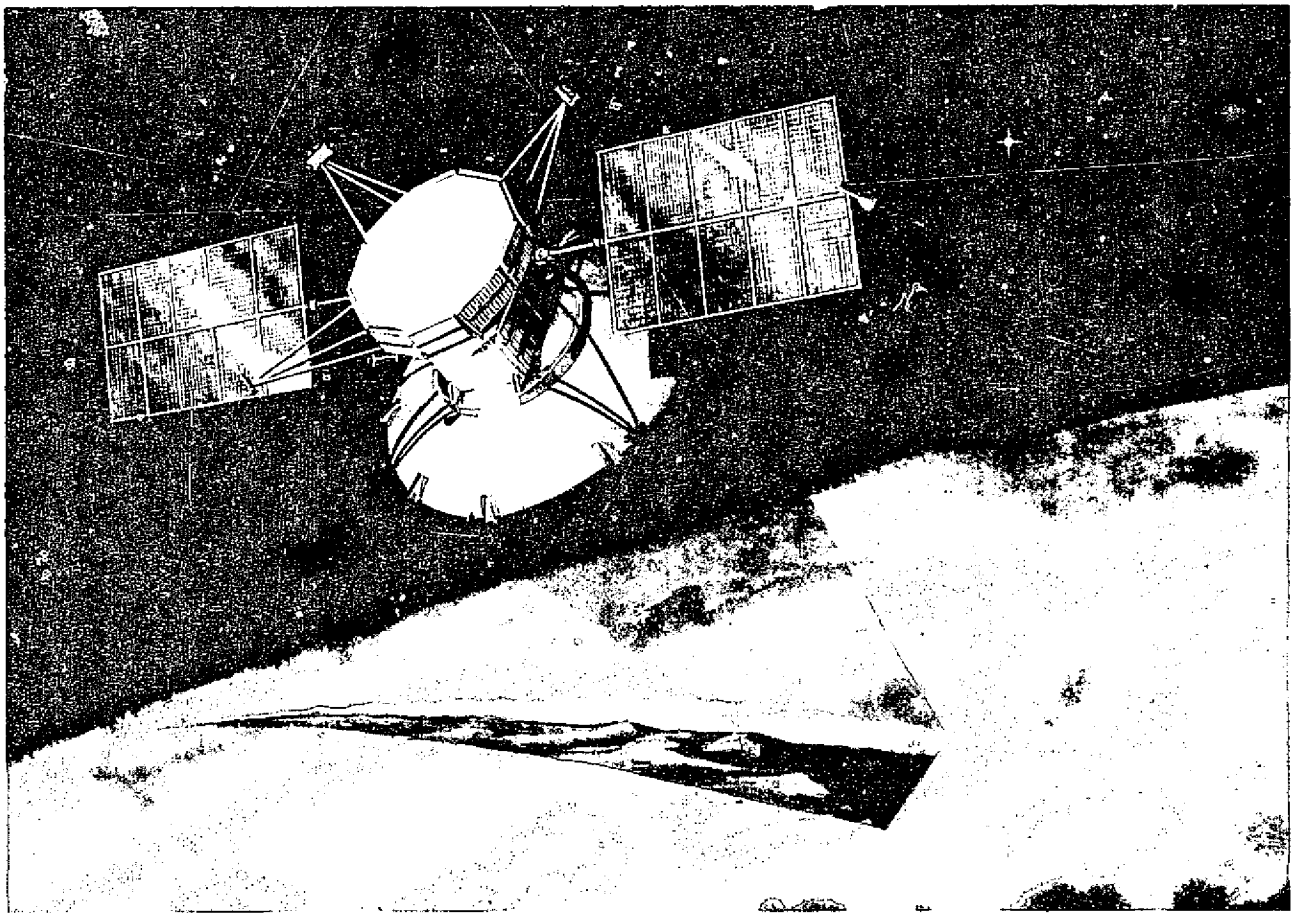
Phased Planetary Activities



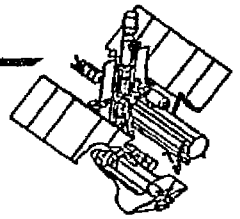


Planetary–Venus Radar Mapper



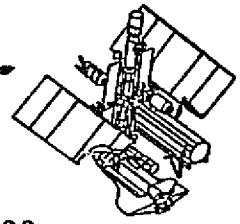


Consolidated Planetary Requirements

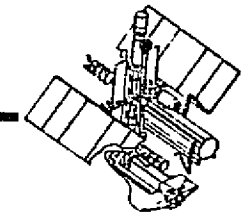


- Capabilities Required
  - Return Sample Retrieve/Quarantine
  - Onorbit Assembly/Integration
- Technology Development Needed
  - Aerobraking Techniques
  - Space Assembly Techniques

Common Themes



- Each Discipline Focuses on a Cornerstone Set of Programs and Missions.
- Each Discipline Has Achieved a Significant Level of Maturity and Progress.
- In the 1995 to 2000 Timeframe, Each Discipline Will be Applying Specialized Techniques (e.g., Interferometry), and use large instruments.
- Disciplines Show, as a Result, a Common Category of Needs and Capabilities For:
  - Variety of Orbits
  - Assembly/Test on Orbit of large instruments
  - Extensive Data Management
  - Onorbit Calibration Facilities
- Data Will be consolidated into User Missions Concept Document for Engineering Analysis on the project.

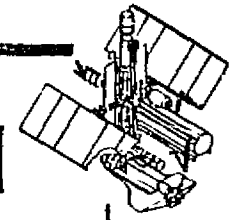


User Missions

Solar Physics And Earth Observations

S. Pompea

Space Station Study Flow



From User Communities

Science | Applications | Commercial | Space Ops | National Security | Foreign User*

*Integrated by NASA

1982 — Time-Phased Objectives — 2000

Benefits
- Social
- Economic
- Performance

User Rqmts Validation
- USRA
- Scientist
- NASA
- Ball
- Infotech
- Etc

Consolidated Discipline Rqmts ↔ Operational Requirements
- Service
- Assembly/ Construction
- Delivery/ Retrieval
- Etc

STS/SS/IFF Analysis | Technology Assessment

Mission Functional Analysis Accommodations

User Mission Reqmts
Solar
Astronomy

Technology Development Reqmts & Plan
- Large Structure Assy
- Thermal Control
- Attitude Control
- Etc

Iteration

Integrated User Mission Reqmts
SS Mission Model

Detailed Reqmts Definition

Program Options
- Single Station
- Multiple Stations
- Low Early Cost
- Etc

Space Station Support Reqmts

Arch. Option to Support Program Options

Cost, Schedule & Benefits Analysis

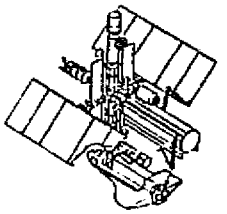
Element Definition & Characteristics

Recommend Space Station Architectural Concept/Attributes → Initial Capability → Growth Increments → Ultimate Capability

REQUIREMENTS TRACEABILITY

E-2

Solar Physics

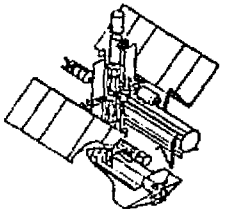


GOAL

TO UNDERSTAND THE FUNDAMENTAL PHYSICAL PROCESSES OF THE SUN

MAJOR ELEMENTS	KEY OBJECTIVES
• SUN AS A STAR	• SOLAR INTERIOR • SOLAR STRUCTURE • SOLAR VARIABILITY
• ACTIVE SUN	• CORONA & CORONAL HOLE • FLARE PROCESSES • RADIATION DYNAMICS • PARTICLE EJECTION PROCESSES
• HELIOSPHERIC PROCESSES	• SUN-WIND INTERFACE • SOLAR WIND • PLANETARY INFLUENCES • EFFECT ON INTERPLANETARY SPACE

Solar Physics Contact Plan



Contacts Made

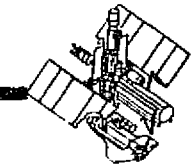
HAO	* R. MacQueen
	* R. Fisher
	* R. Monroe
LASP	* J. Timothy
SPO	R. Dunn
GSFC	W. Neupert
NRC	J. Bartoe
NASA HQ	J. Bohlin

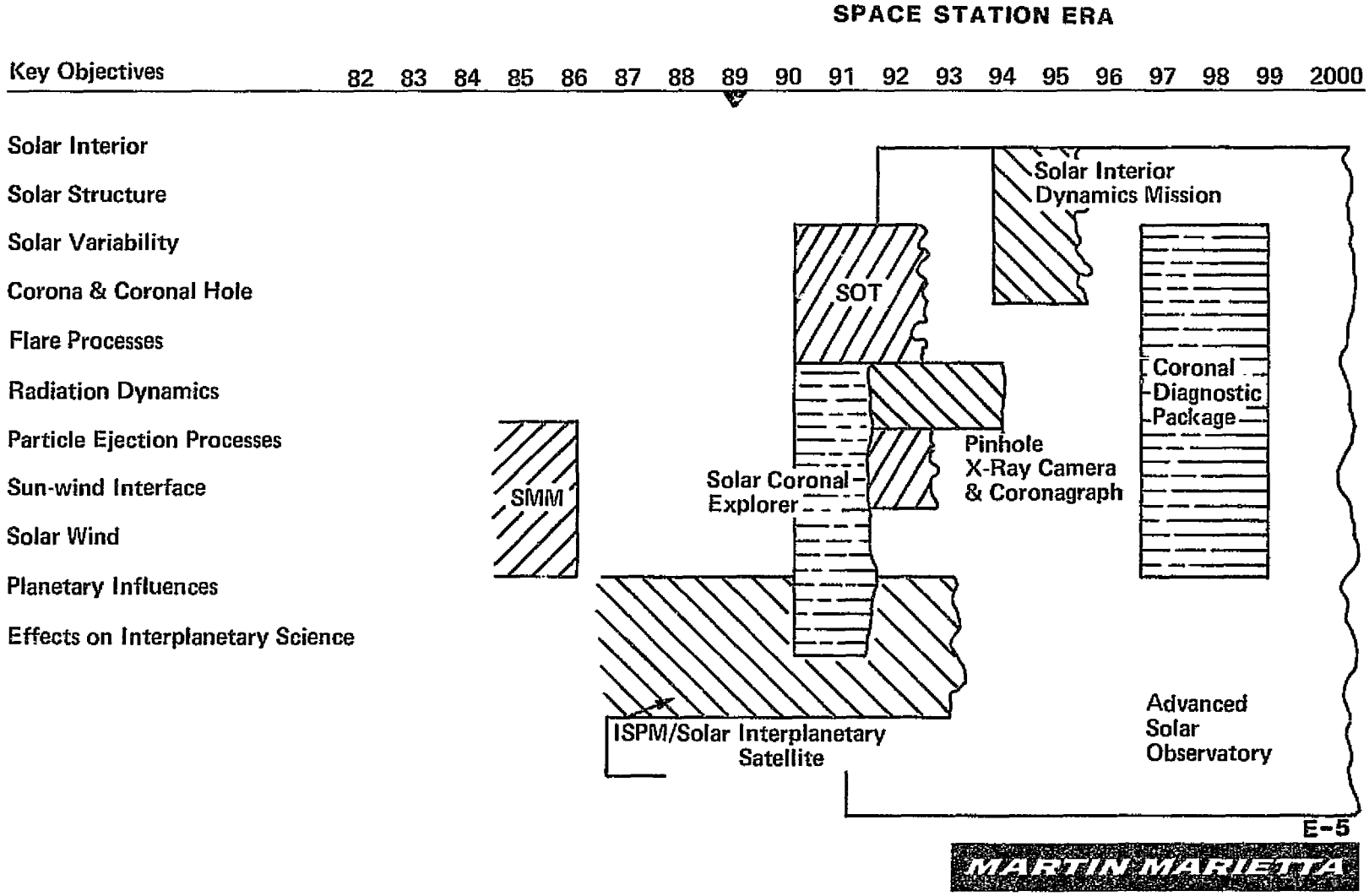
Contacts Planned

Stanford	A. Walker
GSFC	A. Poland
Cal Tech	E. Rhodes
Center for Astrophysics	G. Withbroe
MSFC	E. Tanburg-Hanson
	E. Hildner

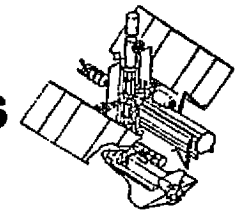
* Contacted In Person

Solar Physics Phased Activities Projection





Consolidated Solar Physics Requirements

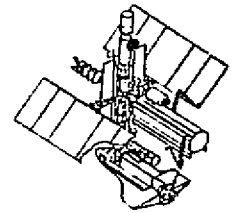


Initial Complement	Ultimate Complement (1)
Universal filter polarimeter	Resonance line coronagraph
• UV spectrograph	• Soft x-ray imaging telescope
Visible spectrograph	EUV diagnostic spectrometer
Pinhole mask/occulter	Magnetograph
X-ray detector	X-ray, XUV, and EUV telescope facilities
Coronagraph/spectrometer	Magnetic field and velocity instruments
• White light coronagraph	Solar global oscillation instrument
• X-ray/XUV telescope	• Solar UV spectral irradiance monitor
Solar x-ray/cosmic-gamma ray burst detector	Solar total irradiance monitor
Solar wind instrument	• Soft x-ray coronagraph
Solar irradiance monitor	
Solar Optical Telescope	

Note:

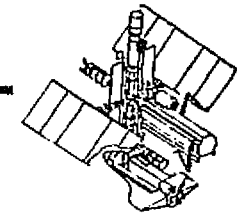
(1) All initial complement instruments also included

Solar Physics
Critical Integration Parameters



- On Orbit Data Processing
- Command Capability to Rapidly Observe Transient Phenomena
- Operational Interalignment
- Continuous Observation of a Feature from Limb to Limb
- Refurbishment of Optical Coatings
- Pointing to 1 Arc-Second
- Low Contamination Environment
- Sun Synchronous, High Inclination Orbit Preferred
- Need Observations over 22-year Cycle

Earth Observations



Goal

To understand the Earth as a system and those changes that may affect man.

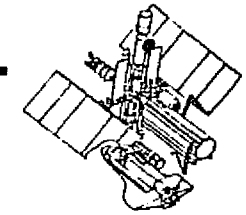
Elements

- Upper Atmosphere
- Weather
- Oceanography
- Climate
- Agriculture
- Natural Resources
- Geophysics

Key Objectives

- Develop Capability to Reliably Forecast Changes in Global Ozone
- Improve Short-and Long-Term Forecasting Capability
- Develop Understanding of Global Circulation and the Capability to Observe Productivity
- Develop Capability to Forecast Seasonal Variability
- Enhance and Manage Agricultural Production, Water Use, and Land Use
- Map and Evaluate Mineral Deposits, Timber, and Watersheds
- Map and Determine Effects of Changes in Magnetic and Gravity Field and Crustal Phenomena

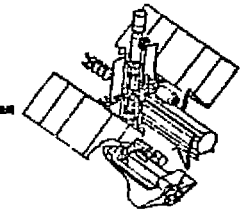
Earth Observations Contact Plan



Contacts Completed

NASA HQ	—	K. Ando, D. Butler, D. McConnel, B. Schardt, S. Tilford, J. Welsh
GSFC	—	W. Barnes, E. Mercanti, E. Speaker
MSFC	—	W. Huber, O. Vaughn
JSC	—	R. Herbert
LARC	—	F. Huck
JPL	—	A. Kahle, R. Stewart
NCAR	—	J. Firor, J. Gille
NOAA	—	F. Hall, G. Little, J. Purdom, H. Yates
USGS, Flagstaff	—	R. Batson, H. Kieffer, G. Schaber, L. Soderblom, S. Wu
Colo State Univ	—	B. Marlatt, J. Smith, T. Von der Haar, G. Wallace
Univ of California, Santa Barbara	—	J. Dozier, J. Estes, D. Simonett, R. Smith
Univ of Wisconsin	—	V. Suomi

Earth Observations Contact Plan (Concl)



Planned Contacts

NASA HQ	—	T. Fischetti, E. Flinn, H. Hogg, J. Moore, W. Piotrowski, F. Von Bun
GSFC	—	R. Coates, L. Meredith
LARC	—	S. Katzberg, N. Murray
JSC	—	V. Whitehead
NOAA	—	W. Hovis
ITEK	—	F. El-Baz
UCSD	—	J. Arnold
Scripps Inst	—	R. Somerville, C. Gauthier
Purdue	—	D. Landgrebe
Univ of Miami	—	O. Brown

Validation

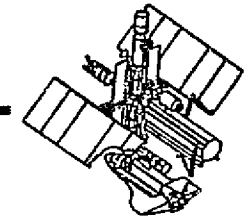
- Reviewers from Universities Space Research Assoc.
- Researchers in Fields of Atmospheric Sciences, Oceanography & Geological Sciences
- Principal Investigators on Planned Earth Observation Missions

Summary

36 Contacts

— 15 NASA
— 11 NCAR, NOAA, USGS
— 10 University

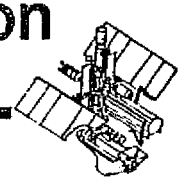
Evolution Of Earth Observation



Measurement Needs

	Current	Near-Term	Far-Term
Upper Atmosphere	– Aerosols – Ozone – Minor Species	– Simultaneous – Winds	– Simultaneous – Long-Term – Calibration – Lidar
Global Chemical Cycles	– None	– Sensor Testing (Maps)	– Lidar – High Spatial Resol
Weather	– Soundings – Clouds	– Geostationary – Sounding (Microwave)	– Lidar – Precipitation
Climate	– Solar Const – Radiation – SST – Currents	– Surface Winds – Global Radiation	– Long-Term – High Precision – Calibration
Oceanography	– Winds – Topography – Color – Temperature	– Wave Spectra	– Simultaneous – Microwave
Geology and Geophysics	– Geodesy – Crustal Dynamics	– Mapping	– Multispectral – Synthetic Aperture Radar

Phased Earth Observations Activities Projection



Space Station Era

80 82 84 86 88 90 92 94 96 98 2000

UPPER ATMOSPHERE
- UARS
- LIDAR (STS)

METEOROLOGY
- GOES →
- NIMBUS
- TIROS N

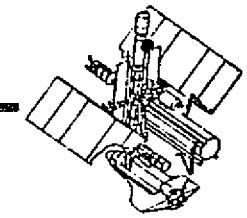
OCEANOGRAPHY
- TOPEX
- NOSS-B
- PASS MICRO

CLIMATE
- ERBS
- ISCCP →

NATURAL RESOURCES
- AEROS
- SMIRR
- MAPSAT
- LANDSAT D
- ADV Geology
- FIREX
- SIRA
- SIRB

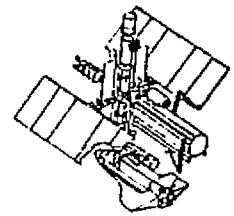
GEOPHYSICS
- G Grad
- M Grad

Consolidated Earth Observations Requirements

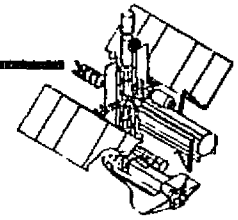


1990	Orbital Requirements
• Synthetic Aperture Radar	LEO, High Inclination
• Imaging Spectrometer: Visible/IR	LEO, High Inclination
• Cryogenic Limb Scanning Interferometer and Radiometer	LEO, High Inclination
• Earth Radiation Budget	LEO, High Inclination
• Stereo Visual Imager	LEO, High Inclination
• Microwave: Active and Passive	LEO, High Inclination
• Weather Operations Satellites	GEO
• Geosynchronous Satellite Instrument Intercalibration	LEO, High Inclination
• Radar Altimeter-TOPEX	1300 KM, 65° Inclination
1995	
• LIDAR	LEO, High Inclination
• Thermal IR Imager	LEO, High Inclination
• Gravity Gradiometer	LEO, High Inclination
• Magnetic Gradiometer (Tether)	LEO, High Inclination
• Microwave 100M Diameter (Passive)	GEO

Earth Observations – Critical Integration Parameters



- Need Data Processing because of High Data Rate (Imaging Spectrometer–300 Mbits/s)
- Need Recoverable Data Base
- Variety of Orbits Required (Mostly High Inclination)
- Assemble and Test On Orbit (100-m Antenna)
- Need Simultaneous Data on Sets of Geophysical Parameters
- Low Contamination Environment
- High Power Required - SAR 5 kw, LIDAR 10 kw
- Flash Tube Replacement for LIDAR



Communications

Life Sciences

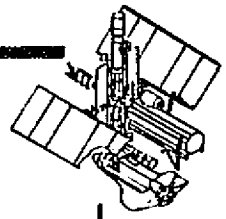
Materials Processing

Commercial

W. Nobles

MARTIN MARIETTA

Space Station Study Flow



From User Communities

Science | Applications | Commercial | Space Ops | National Security | Foreign User*

*Integrated by NASA

1982 — Time-Phased Objectives — 2000

User Rqmts Validation
- USRA
- Scientist
- NASA
- Ball
- Infotech
- Etc

Consolidated Discipline Reqmts ↔ Operational Requirements
- Service
- Assembly/ Construction
- Delivery/ Retrieval
- Etc

STS/SS/IFF Analysis | Technology Assessment

Benefits
- Social
- Economic
- Performance

Mission Functional Analysis Accomm. odations

User Mission Reqmts
Solar
Astronomy

Technology Development Reqmts & Plan
- Large Structure Assy
- Thermal Control
- Attitude Control
- Etc

Iteration

Integrated User Mission Reqmts
SS Mission Model

Detailed Reqmts Definition

Program Options
- Single Station
- Multiple Stations
- Low Early Cost
- Etc

Space Station Support Reqmts

Arch. Option to Support Program Options

Cost, Schedule & Benefits Analysis

Element Definition & Characteristics

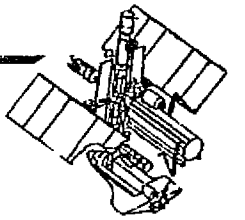
Recommend Space Station Architectural Concept/Attributes → Initial Capability → Growth Increments → Ultimate Capability

REQUIREMENTS TRACEABILITY

F-2

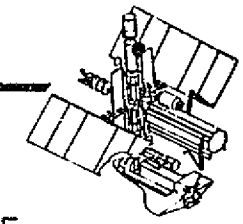
C-2

Communications



Major Elements	Objectives
Telecommunications (Geosync Relay Platforms) - Predicted Growth 7 to 40 X - Teleconferencing - Narrowband Radio Telephone (800 MHz) - Developing Nations	Support Increased Traffic Needs - Develop New Frequencies (K_A Band) - Increase Slot Density - Multibeam/Multiaccess - Sat.-to-Sat. Relay - Increase Platform Capacities - Build-Up & Service Platform
Direct Broadcast TV (Geosync)	Service Remote Areas
Deep Space Relay (Geosync)	Support Deep Space Missions
Search & Rescue (LEO-High Inclination)	Provide Location Capability for Emergency Beacons

Communications Contact Plan



Completed

NASA HQ	G. Knouse
	T. McGunigal
	L. Holcomb
	H. Fosque
MSFC	T. Carey
JPL	Dr. J. Layland
	J. Randolph
Langley	W. Grantham
RCA Astroelectronics	J. Blankenship
RCA Americom	J. Schwarze
GE	M. Van Horn
Hughes	Dr. H. Rosen
Comm Center of Clarksburg	W. Morgan

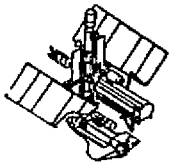
Planned

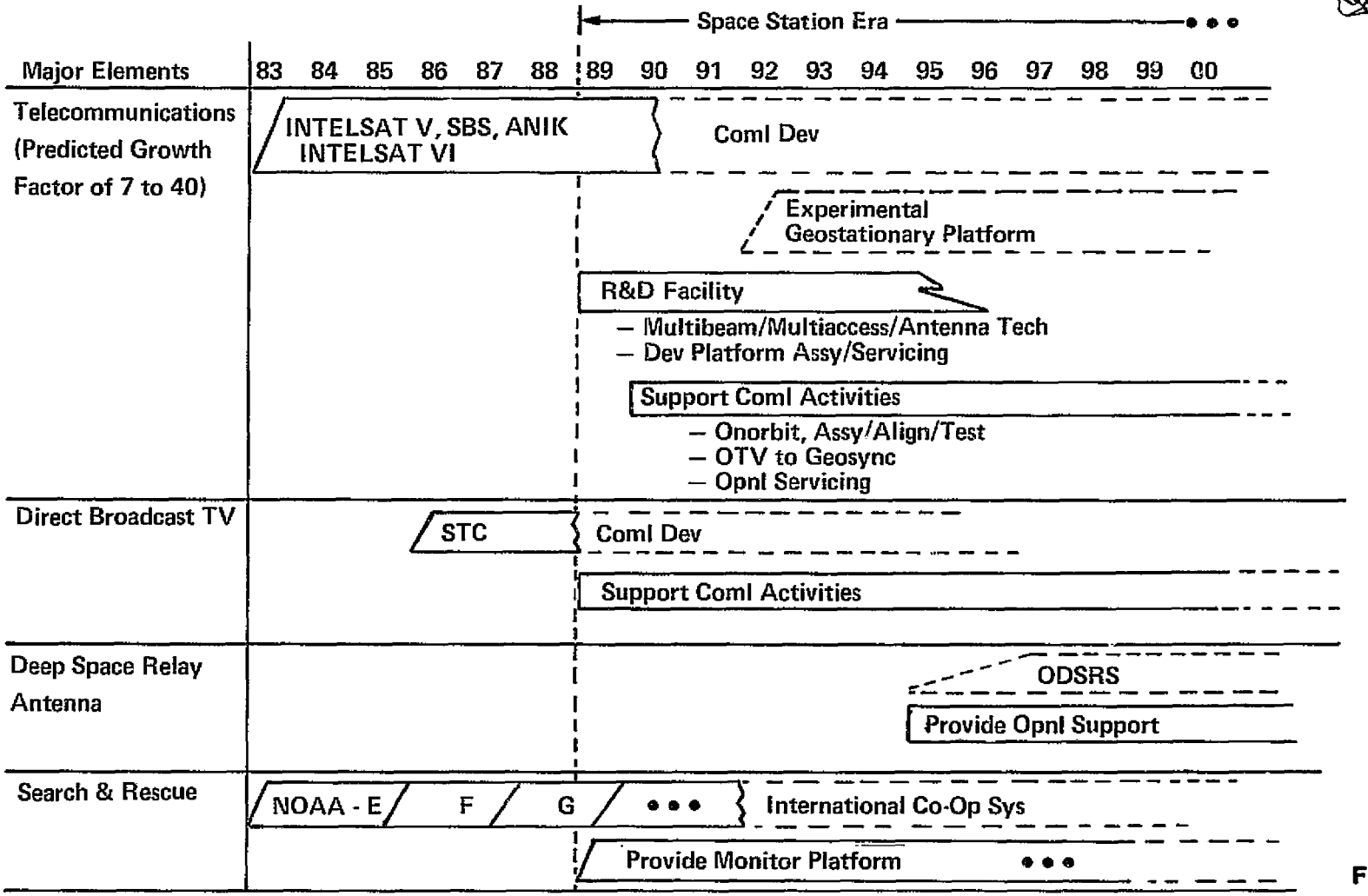
NASA HQ	S. Fordyce
GSFC	J. Schwartz
JPL	R. Dickinson
FCC	
Ford Aerospace	C. Cuccia
COMSAT	Dr. G. Gordon
INTELSAT	D. Sachder
Future Systems	R. Stamminger

Validation

NASA HQ	T. McGunigal
	H. Fosque
MSFC	T. Carey
	Dr. J. Layland
	R. Dickinson

Communications – Activities Projection





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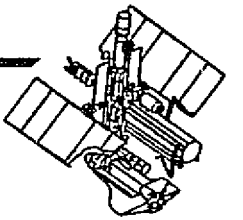
Consolidated Communications Requirements



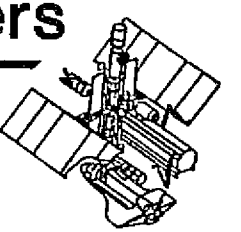
PROVIDE R & D FACILITIES

- ANTENNA PERFORMANCE TESTING
- CLUSTERED ANTENNA PLATFORMS
- MULTIBEAM/MULTIACCESS TECHNOLOGY
- INTEGRATED PLATFORM BUILDUP & SERVICING TECHNOLOGY

PROVIDE OPERATIONAL SUPPORT (COMMERCIAL & GOVERNMENT)

- ONORBIT ASSEMBLY, CHECKOUT, OTV MATING
- OTV DEPLOYMENT TO GEOSYNC
- GEOSYNC PLATFORM BUILDUP & SERVICING

Communications - Critical Integration Parameters



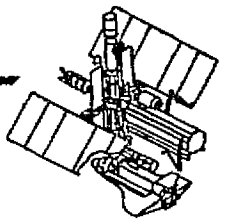
Antenna Test Facility

- 2 kw Power
- Pointing-1 ARC Min
- Onorbit Assembly

Support Facilities (Geosync)

- Retrievable OTV
- Satellite Servicing/Retrieval
- Platform Assembly

User Missions - Life Sciences



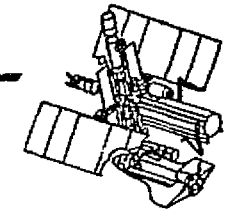
Major Elements

- Vestibular, Neurophysiology
- Cardiovascular, Cardiopulmonary
- Electrolytes, Fluid Imbalances
- Hematology, Immunology
- Musculoskeletal
- Nutrition, Metabolism
- Embryology, Developmental Physiology
- Radiation Biology
- Bioengineering
- Botany
- Medical Operations
- Behavior/Psychology

Objectives

- Understand Complex Physiological Responses to the Space Environment
  - Identify potential hazards to health and comfort of the crew
  - Develop countermeasures
- Establish an Integrated Multi-Disciplinary Life Sciences Research Program
  - Multiple plant and animal species
  - Coordinated team approach
  - Inflight flexibility

Life Sciences Contact Plan



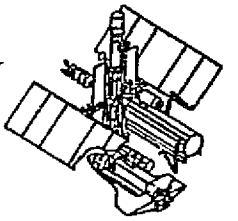
Contacts Made

Organization	Individual	Organization	Individual
UCSF	C. Arnaud*	MATSCO/JSC	M. Buderer
	B. Haverlin		G. Salinas
	B. Cann*	MATSCO/ARC	C. Dant
VCU	G. Musgrave*	MATSCO/Wash	R. Hoffman
UT, Houston	J. Duke	UT, Galveston	M. Correia
Rice Univ	H. Ward*	Brooks AFB	C. Alexander
Baylor Univ	C. Dunn*	Univ of Penn	P. Stein
NASA/JSC	M. Reschke*	USA-MRICD	C. Pascuzzo
	C. Leach*	Oregon Med Sch	L. Gronke
NASA/ARC	N. Daunton	Cornell Univ	J. French
	L. Kraft	CU, Denver	J. Levinson

Validation

Key Investigator Reviews*
USRA - R. Johnston, C. Alexander

Life Sciences Contact Plan (Concl)



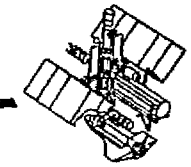
CONTACTS PLANNED

ORGANIZATION	INDIVIDUAL	ORGANIZATION	INDIVIDUAL
TULANE	K. BRIZEE	NIH	D. WHEDON
MIT	L. YOUNG	KSC	B. KNOTT
	C. OMAN	UT, HOUSTON	H. SCHELD*
DEFENSE RES ESTAB,		BROOKS AFB	W. WOLFE
CANADA	K. MONEY		D. JONES
SAN JOSE ST UNIV	R. FOX		J. PICKERING
WRIGHT ST UNIV	G. CRAMPTON		G. WEST
	J. LUCOT		D. SPOOR
NASA/ARC	B. MEHLER	HARVARD	M. MOORE-EDE
UNIV OF PENN	A. BROWN	NASA/ARC	R. MAH
ST UNIV OF NY	A. KRIKORIAN	UC, BERKELEY	N. PACE*
UC, RIVERSIDE	C. FULLER	NAVAL AEROSPACE	GEUDRY
EMORY UNIV	V. POPOVIC*	RESEARCH CENTER	
UNIV OF LOUISVILLE	X. MUSACCHIA*	BAYLOR	A. LEBLANC

VALIDATION

KEY INVESTIGATOR REVIEWS*
USRA - R. JOHNSTON, C. ALEXANDER

Life Sciences – Activities Projection



Space Station Era ——●●●

1980 82 84 86 88 89 90 92 94 96 98 2000 02 04 06 08

Shuttle
- SL1
- SL3
- D1
- SL4
- SL10

△ △ △ △ △

IOC
- Space Sickness
- Orthostatic Intol
- Radiation
- Immunological Suppression
- RBC Changes
- Fluid/Electrolytes
- Countermeasures

Immediate Health-Threatening Problems in Humans and Basic Research Issues

FOC
- Musculoskeletal
- Bone Demineralization
- Vestibular Function
- Nutrition Metabol
- Plant Dev Physiology
- Fluids/Electrolyte Imbalances

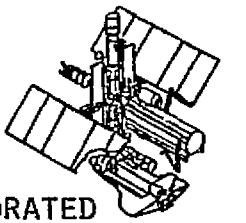
Basic Physiological Responses to Long-Duration Space Environment Exposure

Advanced
- Embryology
- Plant & Animal Dev
- Mutagenicity
- Radiation Biology

△——→

Basic Research Questions Requiring Complex or Continuous Manned Operations or Long-Lead Technology

Consolidated Life Sciences Requirements



INITIAL OPERATIONAL CAPABILITY

BASIC FIRST AID AND BIOMEDICAL RESEARCH AREA INCORPORATED INTO HABITABILITY AREA/MODULE

- CLINICAL, DIAGNOSTIC INSTRUMENTATION
- PHYSIOLOGICAL MONITORING DEVICES
- FIRST AID AND TRAUMA TREATMENT FACILITY
- RECOMPRESSION CAPABILITY
- MINICENTRIFUGE
- EXERCISE EQUIPMENT
- GAS ANALYZER
- STORAGE AND POWER FOR CARRY-ON EXPTS.
- REFRIGERATED STORAGE
- BLOOD COLLECTION KIT
- URINE MONITORING SYSTEM

FULL OPERATIONAL CAPABILITY

AREA/MODULE DESIGNED TO SUPPORT RESEARCH

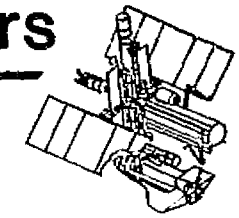
- ANIMAL HOLDING FACILITIES
- WORK STATIONS (BIOCHEMICAL AND SURGICAL)
- STRICTLY CONTROLLED ENVIRONMENT
- INSTRUMENTED PRIMATE FACILITY
- VESTIBULAR INSTRUMENTATION
- ANIMAL CENTRIFUGE
- PLANT FACILITIES

ADVANCED OPERATIONAL CAPABILITY

MODULE(S) DEDICATED TO LIFE SCIENCES RESEARCH

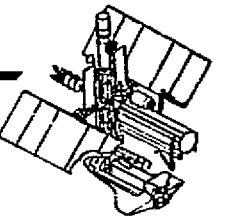
- CONTINUOUS MANNED INTERACTION
- COMPLEX EXPT. PROCEDURES AND HARDWARE
- INFLIGHT EXPT. FLEXIBILITY
- LONG-TERM ANIMAL & PLANT FACILITIES

Life Sciences – Critical Integration Parameters



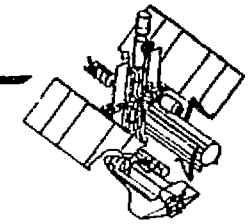
Parameters	-	Equipment Sizing (Stowed & Deployed) - Power - Consummables - Weight
Initial Operational Capability	-	First Aid and Biomedical Research Area • Recompression Facility • Exercise Equipment • Dynamic Imaging Devices • Refrigerators • Surgical Table
Full Operational Capability	-	Life Sciences Research Module • Vestibular Instrumentation (Sled, Rotators, Vertifuge) • Animal Centrifuge (3.7m Diameter) • Isolatable Animal & Human Research Areas • Large Primate Facility • Isolated Infirmary (Quarantine)
Advanced Operational Capability	-	• Multiple Research Modules • Long-Term Animal & Plant Facilities

Materials Processing



Major Elements	Objectives
• Crystal Growth	• Control growth interfaces to eliminate inhomogeneities and defects
• Metal & Alloys Solidfication	• Eliminate influence of convection, sedimentation, and density differences during solidification
• Containerless Processing	• Eliminate physical contact with specimen during processing
• Fluids & Chemical Processing	• Isolate nongravitational effects
• Biomedical - Electrophoresis - Isoelectric Focusing - Blood Rheology	• Improve separation of cells and proteins • Study blood properties

Materials Processing Contact Plan



Completed

JPL	T. Wang
	D. Elleman
	D. Kerrisk
MSFC	W. Adams
	J. Williams
	H. Atkins
	R. Snyder
	J. Horton
Lehigh Univ	Dr. Macaully
LARC	J. Singh
LERC	D. Stalnaker
BASD	L. Greenwood
JSC	K. Demel
Martin Marietta Labs	J. Chen

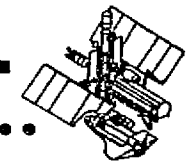
Planned

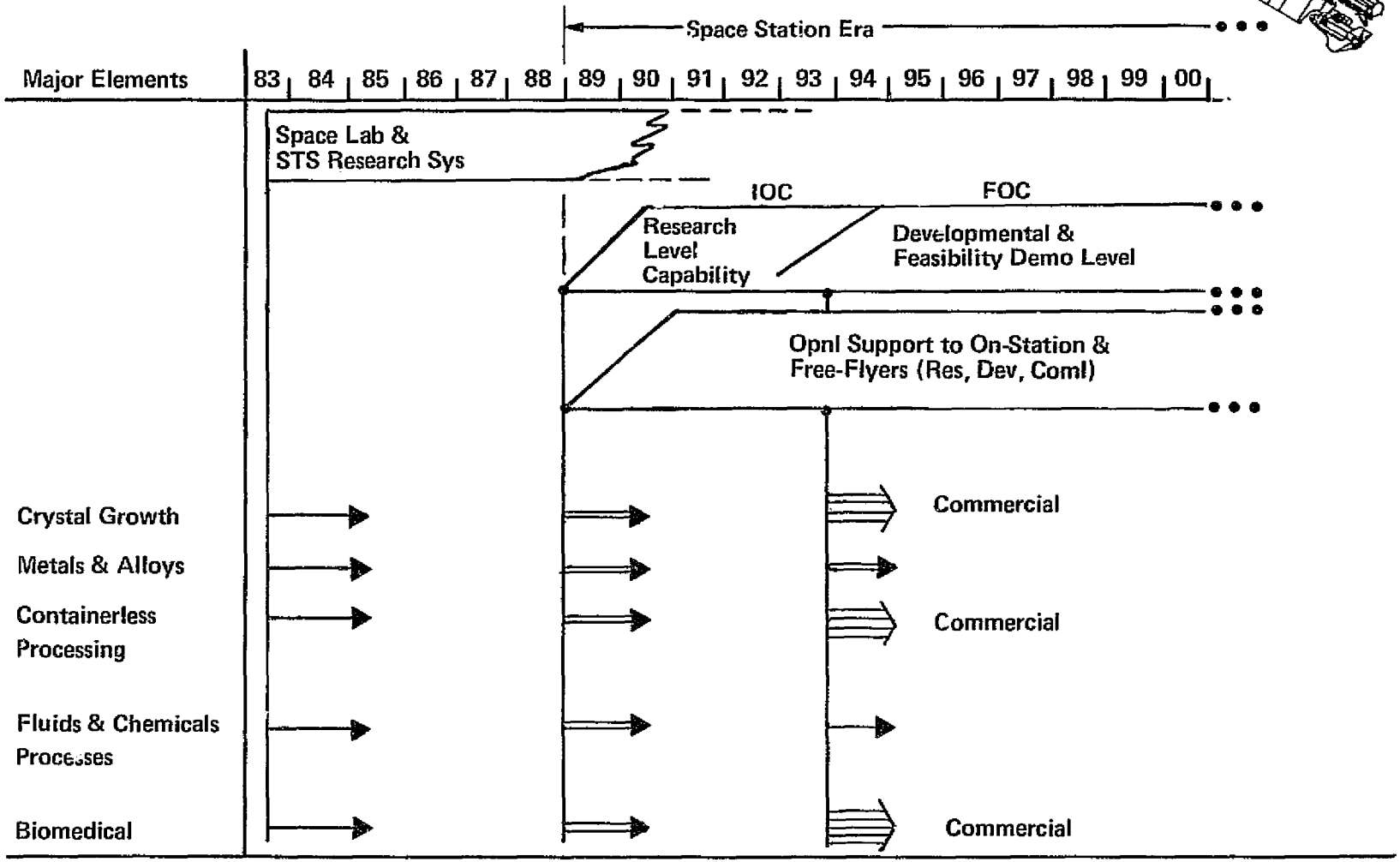
MSFC	Various Personnel
GTI	Commercial
MRA	Commercial
LARC	TD Missions
	Mol Wake Shield
AERC	Comb. Research
MIT	Matl Lab
Princeton	Comb. Research
GSFC	TD Missions
Fairchild	Commercial

Validation

USRA	
MSFC	R. Snyder
JSC	K. Demel

Materials Processing – Activities Projection





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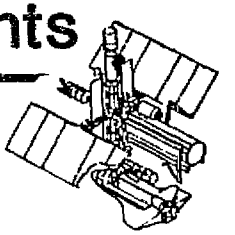
Consolidated Materials Processing Requirements



IOC — Support Research-Level Activities

- Accommodate Discipline-Wide Range of Technologies
- Systems to be Sized for Research
- High Degree of Flexibility
- Provision of Ultrahigh Vacuum
- Extended Duration Experiments
- Accommodate Both Onstation and Free-Flying Systems
- Accommodate Commercial Production Systems

FOC — Support Developmental & Operational Level Activities

- Systems Sized to Demonstrate Production Feasibility
- Capability Growth in Response to Developments
- Accommodate Prototype Commercial Systems

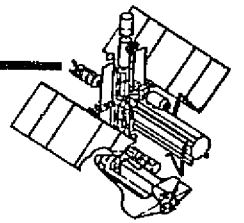
General — Operational Support to Free-Flyer Commercial Materials Processing Satellites as Required

Materials Processing Critical Integration Parameters

- External Influences
  - Gravity: 10^{-4} to 10^{-5} All
  - Motion: Zero Rotation (Liquid Phase Processing)
- Duration - Up to 30 Days (Batch Process Time)
- Power - Up to 25 kw (Containerless Processing)
- Energy - 100 kwh (Typical Zone Refining Process)
- Orbit Altitude/Inclination - Any
- Periodic System Recovery/Resupply
- Operator Intervention/Control

Approach To Developing Space Processing Users

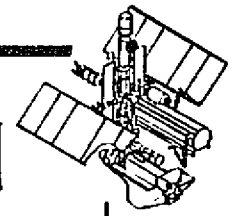
- Based on Review of Past Surveys and Analyses
- Builds on MSFC Contacts and Efforts
  - Benefits from Education and Later Thinking
  - Select Best Candidates (10% to 20%)
  - Contact Same People in Selected Companies
- Two-Man Team for Recontact
  - Space Station Team Member
  - Product-Knowledgeable Specialist
- Introductory Briefing by Space Station Member
  - Future Possibilities Needed, Not Immediate Projects
  - Company Funding and Proprietary Data are Not Issues
  - Important to Meet Future Foreign Competition
  - Company can Help Direct Related NASA Research
- Discussion Led by Product-Knowledgeable Specialist
  - Assures Technical and Business Communication
  - Stresses "What If" and Stimulate Ideas
  - Help Obtain Value Estimates



Space Station and User Requirements Analysis

G. Stone

Space Station Study Flow



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Element Definition & Characteristics

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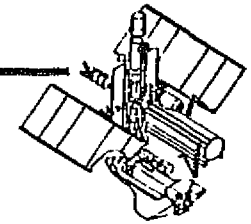
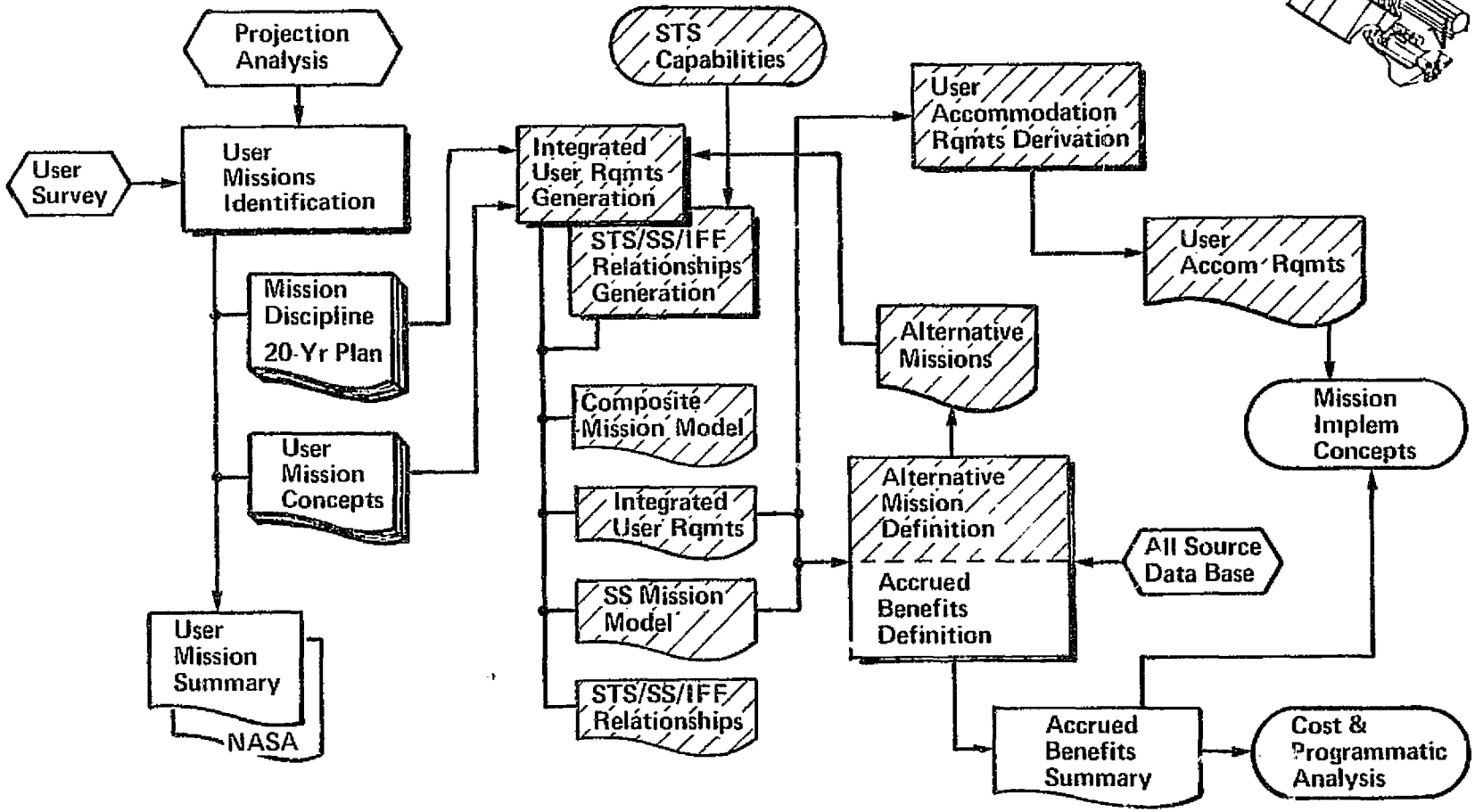
REQUIREMENTS TRACEABILITY

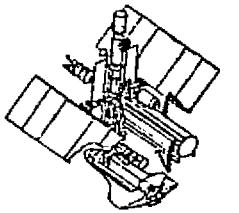
G-2

Task Flow





SS And User Requirements

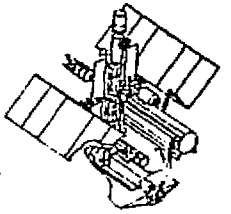


OBJECTIVE: DERIVE SPACE STATION REQUIREMENTS BASED ON USER NEEDS

TASKS:

- DEVELOP COMPOSITE MISSION MODEL
- EVALUATE STS/SPACE STATION/IFF RELATIONSHIPS
- DEVELOP INTEGRATED USER REQUIREMENTS AND ESTABLISH A SPACE STATION MISSION MODEL
- DEVELOP USER ACCOMMODATIONS REQUIREMENTS
- EVALUATE ALTERNATIVE MISSION APPROACHES AND REQUIREMENTS
- PROVIDE REQUIREMENTS VALIDATION/TRACEABILITY

Composite User Mission Model



PURPOSE: DEVELOP AN INTEGRATED MISSION MODEL TO REFLECT THE USER COMMUNITY REQUIREMENTS

- SCIENCE
- APPLICATIONS
- COMMERCIAL
- SPACE OPERATIONS
- U.S. NATIONAL SECURITY

APPROACH:

INPUTS

EXISTING PUBLISHED MISSION MODEL DATA
- NASA MODELS
- BATTELLE MODELS
- NASA TECHNOLOGY MODEL
- OTHER (AIAA, CONTRACTORS)
- DOD MODEL

ANALYSIS

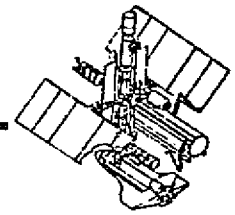
DEVELOP INITIAL MODEL
- ELIMINATE DUPLICATION
- FORMAT
- CATEGORIZE
- ESTABLISH SCHEDULE

UPDATE BASED ON USER CONTACTS
- OBJECTIVES
- TIME PHASING

OUTPUTS

- MISSION MODEL
- DOD ANNEX

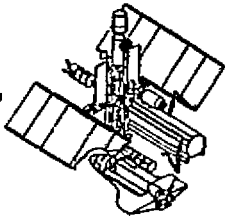
Program Classes And Categories

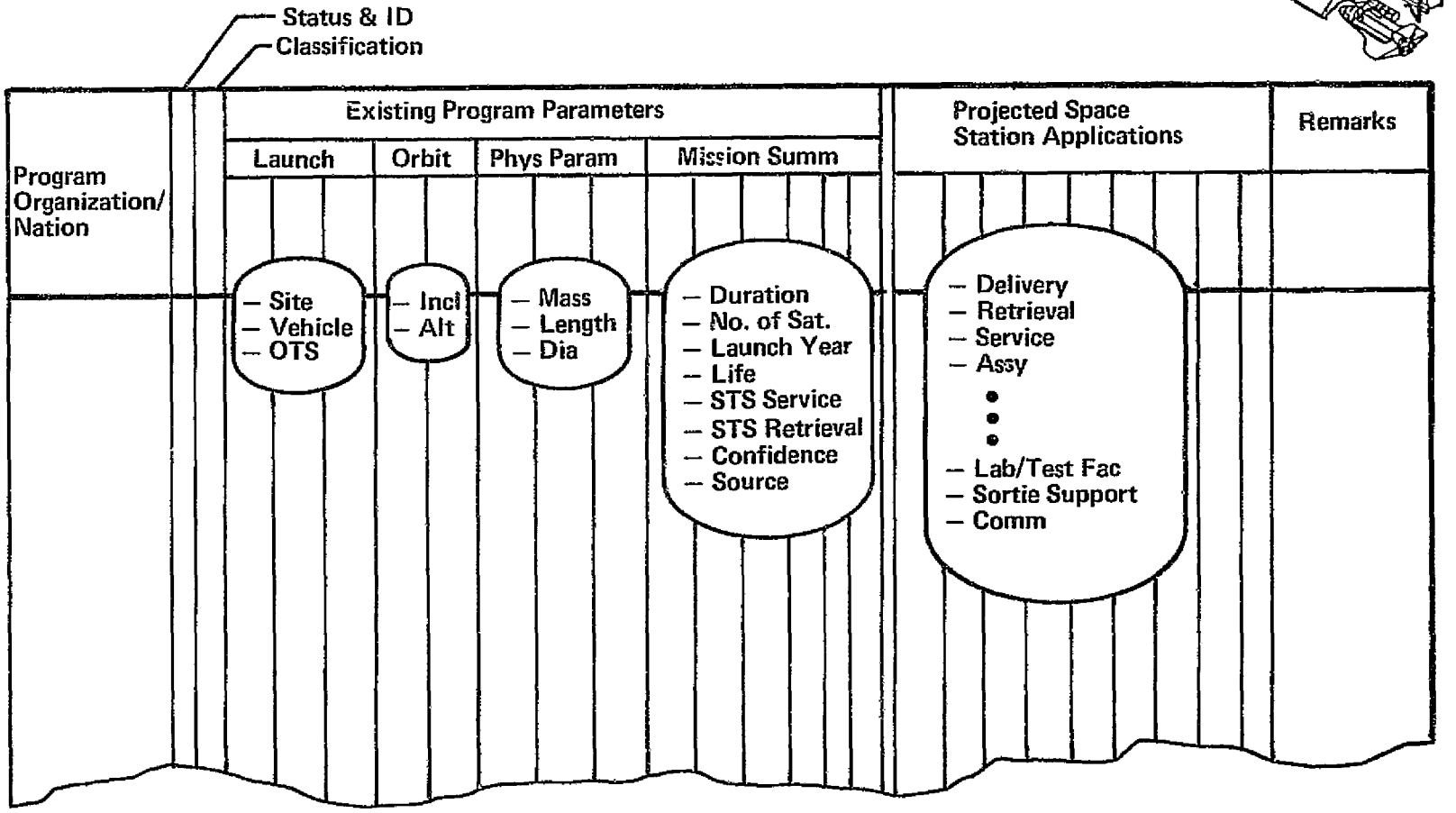


Science		Qty
S-1	Planetary Observation	18
S-2	Earth Observation	49
S-3	Space Physics	4
S-4	Astronomy	37
S-5	Solar Physics	15
S-6	Life/Bio/Medical Sciences	13
S-7	Other	2
Applications		
A-1	Materials Processing	16
A-2	Other	3
Commercial		
C-1	Space Processing	1
C-2	Communications Satellite	59
C-3	Other	3

Space Operations		Qty
O-1	Satellite Servicing	3
O-2	Assembly of Space Structures	5
O-3	Fluid Transfer/Storage	3
O-4	Operating Platform	5
O-5	Launch Transfer	1
O-6	Propulsion	4
O-7	Spacecraft Control	5
O-8	Data Management & Communication	11
O-9	Electrical	4
O-10	Crew Systems	6
O-11	Thermal Control	3
O-12	Other	3
U.S. National Security		
D-1	Existing Programs	~11
D-2	New Programs	
D-3	Space Station Specific Applications	~6
TOTAL		290

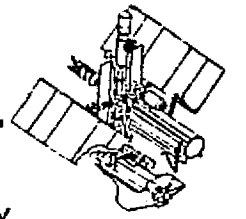
Composite Mission Model





MARTIN MARIETTA

STS/SS/IFF Relationships



PURPOSE: ESTABLISH THE RELATIONSHIP OF USER MISSIONS TO THE STS/SS/IFF BY DETERMINING WHICH SYSTEM BEST SATISFIES THE USER OBJECTIVES AND REQUIREMENTS

APPROACH:

INPUTS

- USER COMMUNITY CATEGORIES
  - TIME-PHASED OBJECTIVES
  - OPERATIONAL REQUIREMENTS
- COMPOSITE MISSION MODEL

EVALUATION

USER OBJECTIVES AND OPERATIONS REQUIREMENTS

- MISSION PLACEMENT
- DURATION
- ENHANCEMENT
  - SERVICING
  - MANNED ATTENDANCE
- SCHEDULE

VS

STS/SS/IFF CAPABILITIES TO BEST SATISFY REQUIREMENTS

- DEVELOP SS OPERATIONS RELATED SCENARIOS
- IDENTIFY SS FUNCTIONAL OBJECTIVE (SERVICE, RETRIEVAL)

OUTPUTS

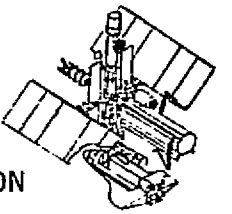
MISSION MODEL APPENDIX

GROUPING OF MISSIONS:

- BEST SATISFIED BY SS 85
- BEST SATISFIED BY STS 16
- BEST SATISFIED BY STS/SS 189

- RELATIONSHIP TO IFF

Integrated User Requirements



PURPOSE: ESTABLISH TIME PHASED SYSTEM AND OPERATIONAL REQUIREMENTS BASED ON USER DISCIPLINE PROGRAM OBJECTIVES AND NEEDS

INPUTS

- USER COMMUNITY OBJECTIVES AND REQUIREMENTS
- UPDATED DISCIPLINE PROGRAM REQUIREMENTS
  - COMPOSITE MISSION MODEL

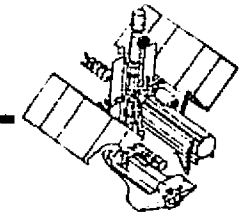
EVALUATION

- ESTABLISH OPERATIONAL CONCEPT FOR DISCIPLINE MISSIONS
  - SS RELATIONSHIPS
  - GROUND RULES
  - SPECIAL SERVICE NEED
  - SPECIAL SUPPORT AND I/FS
  - ESTABLISH ORBITAL PERFORMANCE REQUIREMENTS
- DEVELOP IMPLEMENTATION SCENARIOS
  - DISCIPLINE PROGRAM (TIME PHASED)
  - MISSION
- EVALUATE ALTERNATE MISSION APPROACHES
- VALIDATE CONCEPTS
  - VIA INITIAL DISCIPLINE CONTACTS

OUTPUTS

- INTEGRATED USER REQUIREMENTS DOCUMENT
- SS MISSION MODEL

User Accommodation Requirements



PURPOSE: ESTABLISH THE FACILITY, SYSTEM, AND OPERATIONAL ACCOMMODATIONS REQUIRED TO IMPLEMENT THE SPACE STATION TIME PHASED USER REQUIREMENTS

APPROACH:

INPUTS

- COMPOSITE MISSION MODEL
- INTEGRATED USER REQUIREMENTS
- SS MISSION MODEL

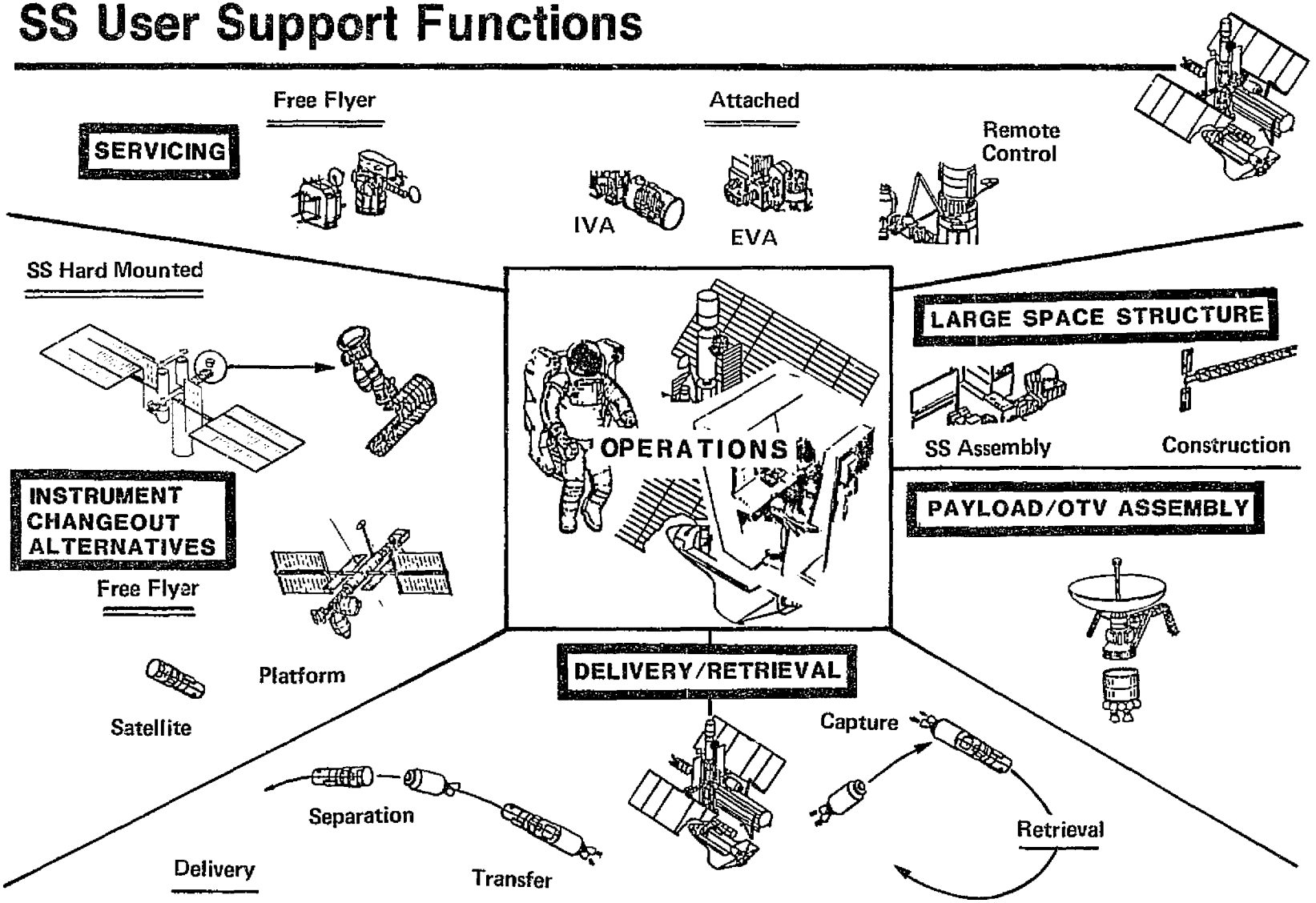
EVALUATION

- ESTABLISH BASIC SS REQUIREMENTS
- PERFORM FUNCTIONAL ANALYSIS
  - POTENTIAL SS FUNCTIONS
  - SPECIFIC USER REQUIREMENTS
- IDENTIFY ACCOMMODATIONS
- TIME PHASED ACCOMMODATIONS

OUTPUTS

- ACCOMMODATIONS REQUIREMENTS DOCUMENT
  - BASIC SS REQUIREMENTS
  - TIME PHASED USER REQUIREMENTS

SS User Support Functions

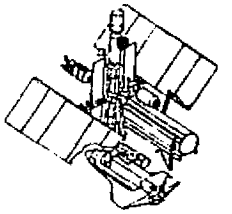


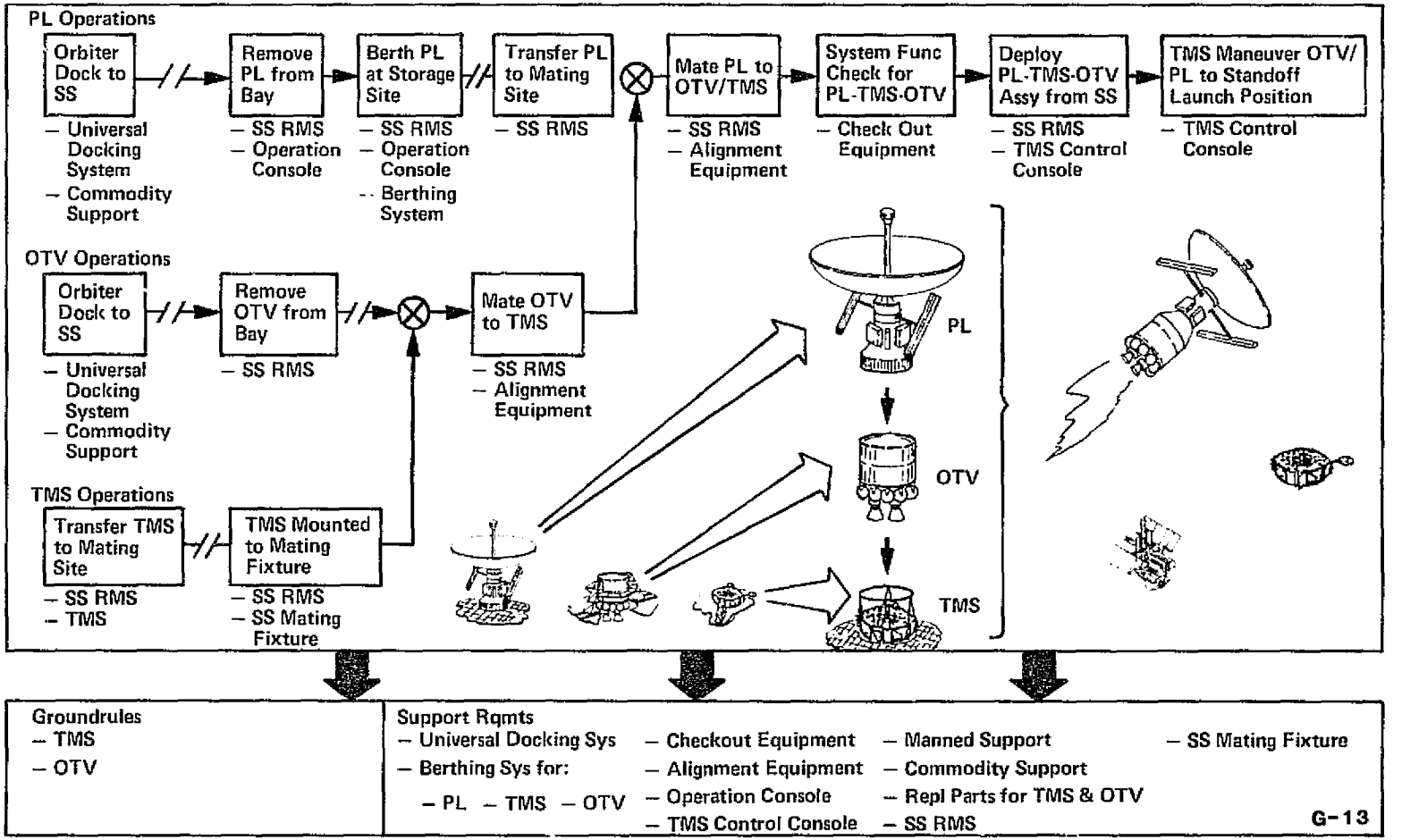
MARTIN MARIETTA

Potential Missions

Servicing	135
Large Space Structures	20
Payload/OTV Assembly	159
Delivery	139
Retrieval	16
Instrument Changeout	85
STS Peculiar	16

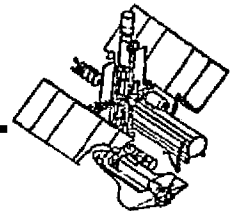
Functional Analysis–Assembly P/L To OTV





MARTIN MARIETTA

Orbit Selection Analysis



PURPOSE: DEFINE OPTIMUM ORBIT LOCATION FOR SPACE STATION TO SUPPORT USER NEEDS

- IDENTIFY VIABLE APPROACHES FOR REQUIREMENT, COST, AND BENEFITS ANALYSIS
- ESTABLISH PERFORMANCE REQUIREMENTS

APPROACH:

ANALYSIS

INPUTS

- NASA DATA
  - JSC MISSION STUDIES
  - STS DATA
  - ATMOSPHERIC DATA
- STUDY DATA
  - MISSION MODELS
  - USER DATA
  - REQUIREMENTS

- OPTIMUM ALTITUDE
  - STS PERFORMANCE
  - DRAG MAKEUP
- OPTIMUM INCLINATION
  - STS PERFORMANCE
  - OTV SIZE & COST
  - TMS SIZE & COST

OUTPUT

- ORBIT SELECTION PARAMETRIC DATA

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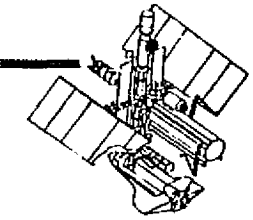
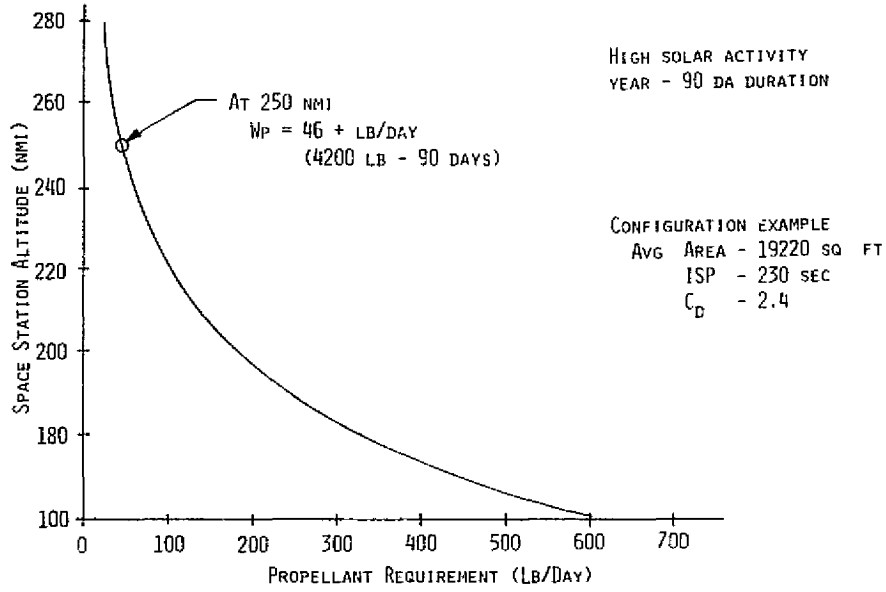
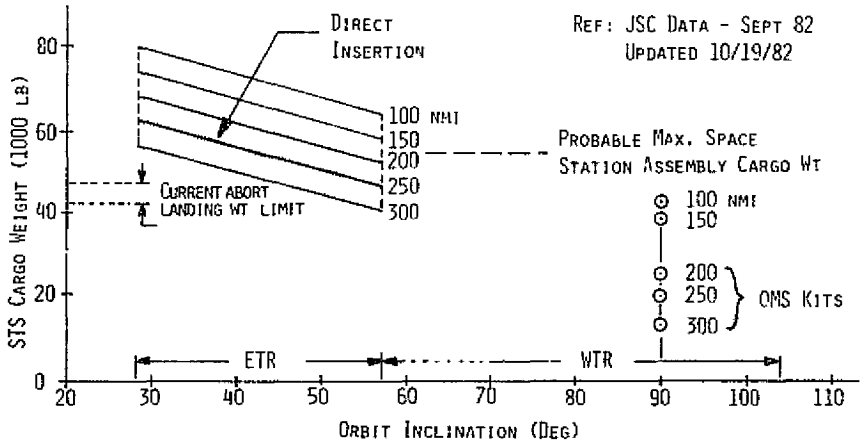
SS Orbit—Preliminary Selection







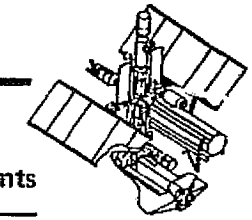
Altitude - 250 nmi

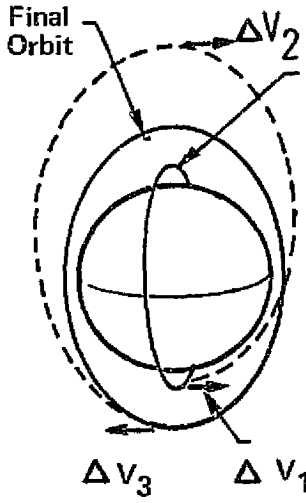
- Above Low-Alt Traffic
- Stationkeeping Prop. Low ~ 46 # / Day
-
- 47-63 klb - ETR STS Insertion
- 55 klb Max Est SS Cargo Wt
- ETR Current Abort Limit - [illegible] klb

Inclin Range 28.5° to 57°

- Desirable ETR PL Range vs 20 to 30 klb for WTR
- Inclin within Range of Wide Mission Spectrum

Evaluate OTV Performance Requirements





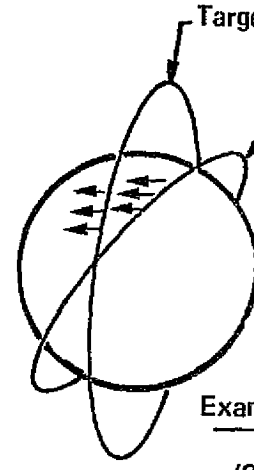
Investigate Maneuver Strategies

(e.g., 57° Orbit to High Polar vs to GEO)

3 Impulses (No Nodal Change)

Group Missions by Orbital Performance Rqmts

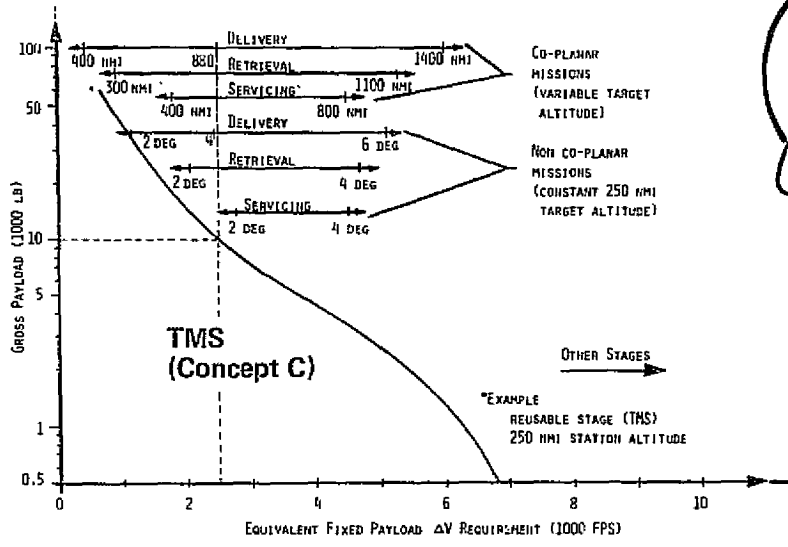
- Near Altitude and Plane
  - Intermediate Energy
    - High-Energy Missions



Examine Launch Window Considerations

(STS vs Space Station Launches)

Examine Candidate OTV Capabilities



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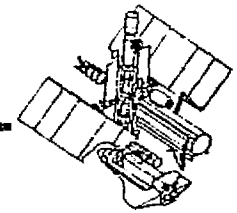
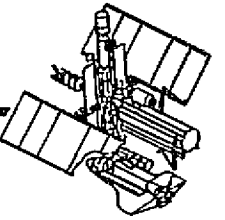
MARTIN MARIETTA

Summary Status



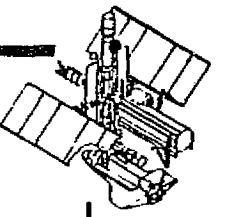
• Composite Mission Model	Initial Issue Released - Update as Required by User Data - 290 Missions Identified
• STS/SS/IFF Relationships	Initial Evaluation 43% Complete
• Integrated User Requirements	Underway
• Accommodation Requirements	Initial Document Released - Basic SS Requirements - Potential SS User Support Functions Evaluated -- Requirements Identified -- Update to User Specific Requirements
• Orbit Selection Analysis	Preliminary Orbit Selection Parametric Data-- In Process
• Requirements Traceability	Maintained by Code to Original Composite Mission Model Missions



Accrued Benefits

T.J. Sullivan

Space Station Study Flow



From User Communities

Science | Applications | Commercial | Space Ops | National Security | Foreign User*

*Integrated by NASA

1982 — Time-Phased Objectives — 2000

User Rqmts Validation
- USRA
- Scientist
- NASA
- Ball
- Infotech
- Etc

Consolidated Discipline Rqmts ↔ Operational Requirements

- Service
- Assembly/ Construction
- Delivery/ Retrieval
- Etc

STS/SS/IFF Analysis | Technology Assessment

Benefits
- Social
- Economic
- Performance

Mission Functional Analysis Accommodations

User Mission Reqmts
Solar
Astronomy

Technology Development Reqmts & Plan
- Large Structure Assy
- Thermal Control
- Attitude Control
- Etc

Iteration

Integrated User Mission Reqmts
SS Mission Model

Detailed Reqmts Definition

Program Options
- Single Station
- Multiple Stations
- Low Early Cost
- Etc

Space Station Support Reqmts

Arch. Option to Support Program Options

Cost, Schedule & Benefits Analysis

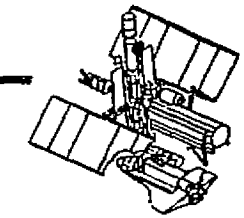
Element Definition & Characteristics

Recommend Space Station Architectural Concept/Attributes → Initial Capability → Growth Increments → Ultimate Capability

REQUIREMENTS TRACEABILITY

H-2

Objective and Scope



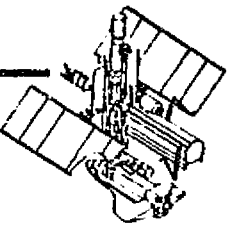
Objective

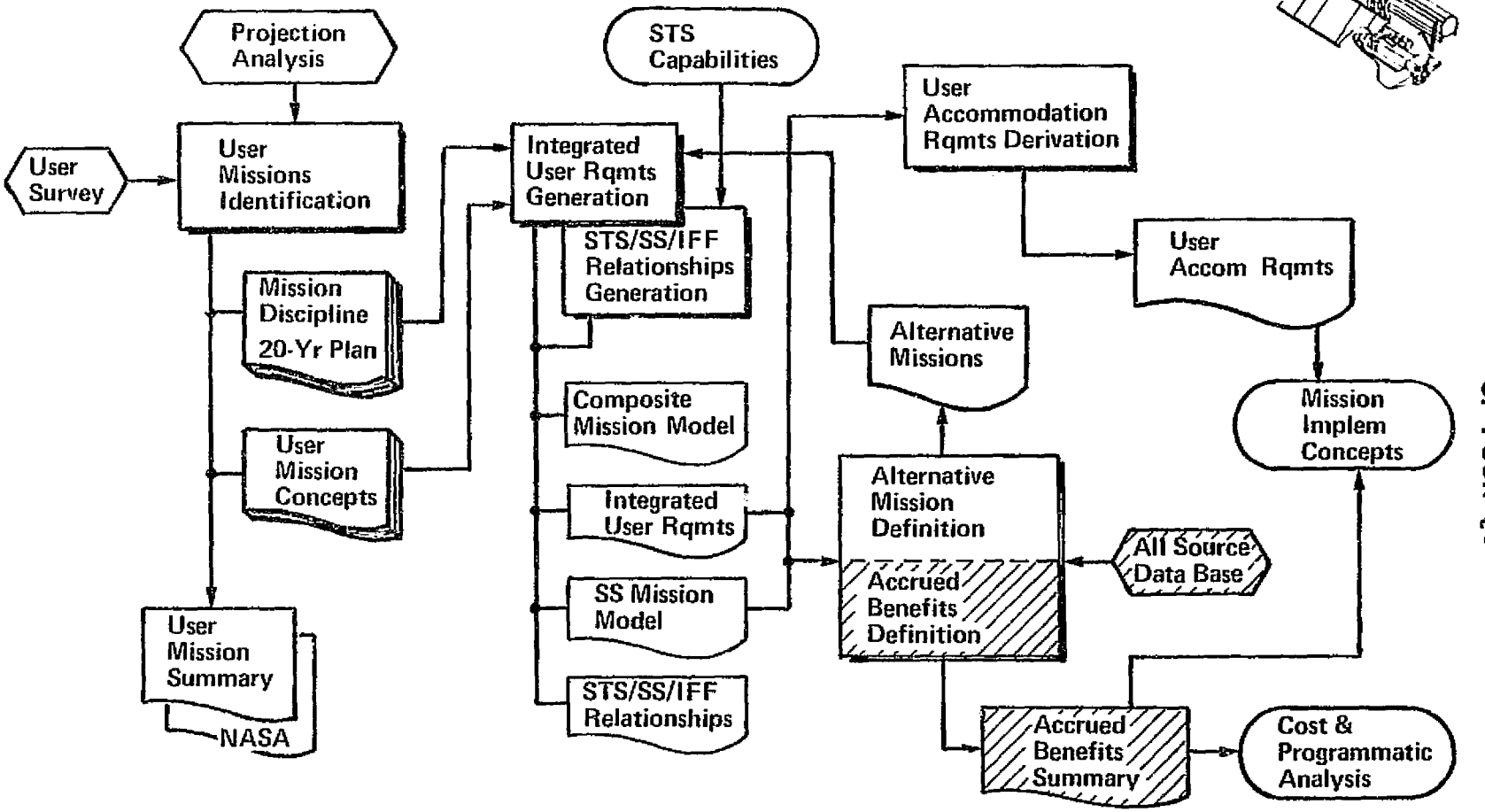
- To identify benefits to be derived by or from user missions for the various mission alternatives.

Scope

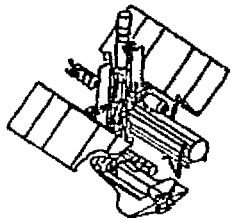
- Analyze all Mission Categories & Disciplines
- Determine SS/STS/IFF Relative Benefits
  - Economic
  - Performance
  - Social

Task Flow





Assumptions, Constraints, and Considerations



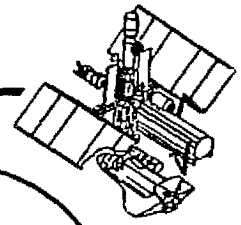
Assumptions and Constraints

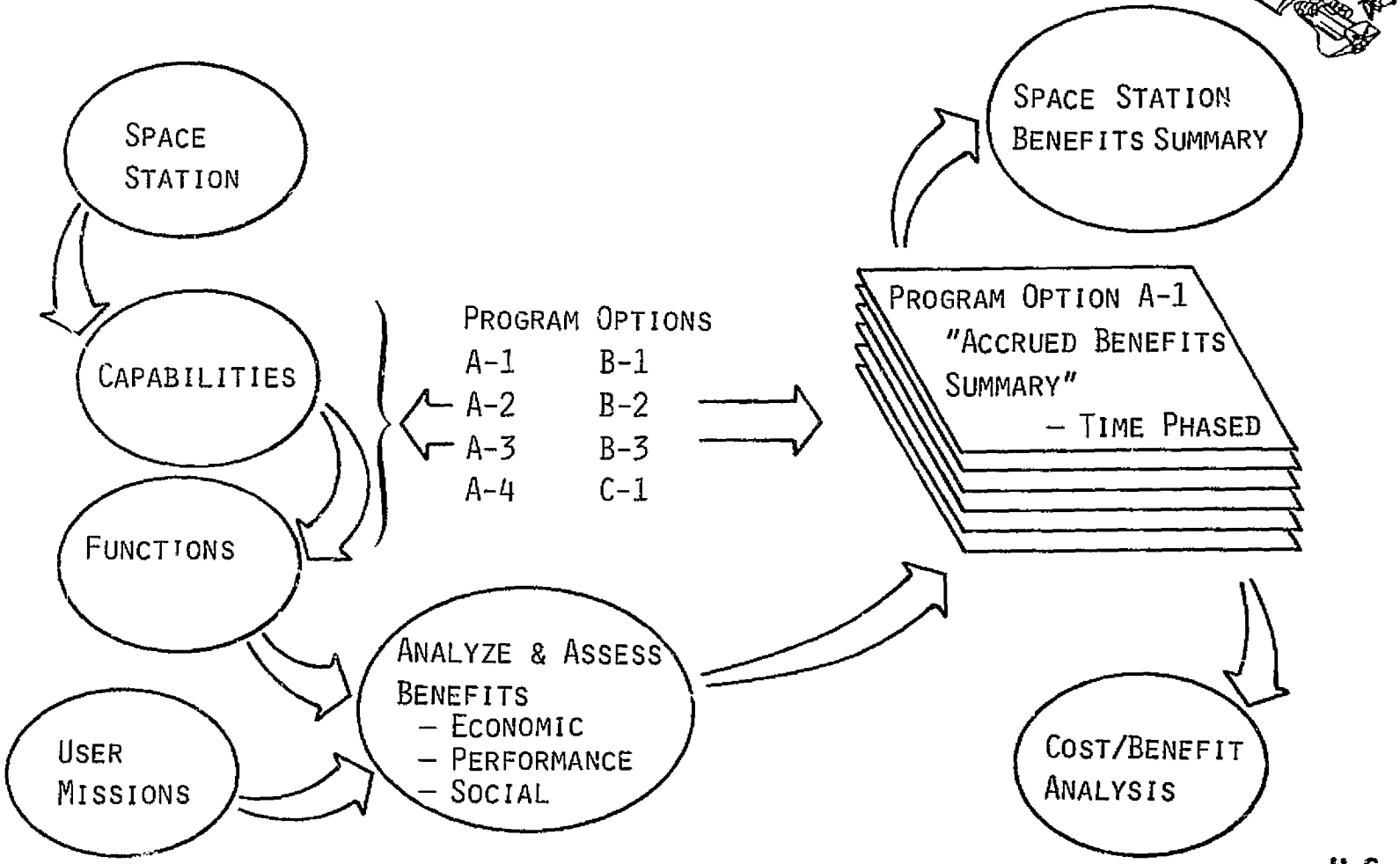
- Space Station Facility
  - Permanently Manned
  - STS Supported
- Time Period of Interest
  - 1985 to 2000

Considerations

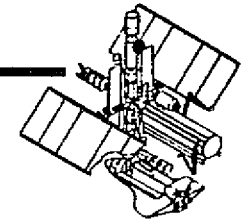
- Sortie Support
- Structure Assembly
- Satellite Delivery/Retrieval
- Satellite Servicing
- Operations Control
- Supply Storage/Repair
- Comm & Data Handling
- Sterilization
- Lab/Test Facility
- Tethered Satellites
- LOD Enhancement
- Safety

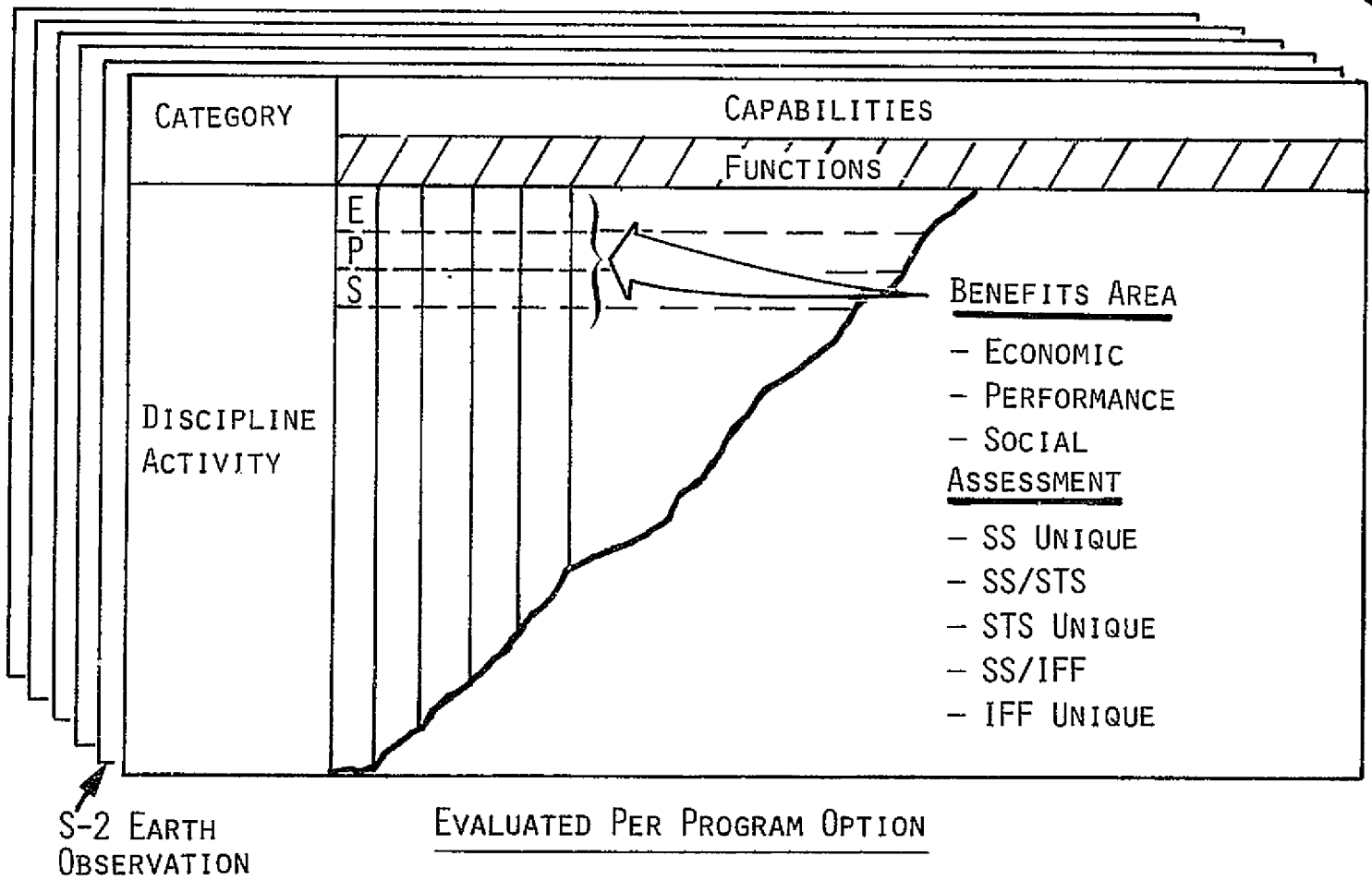
Approach



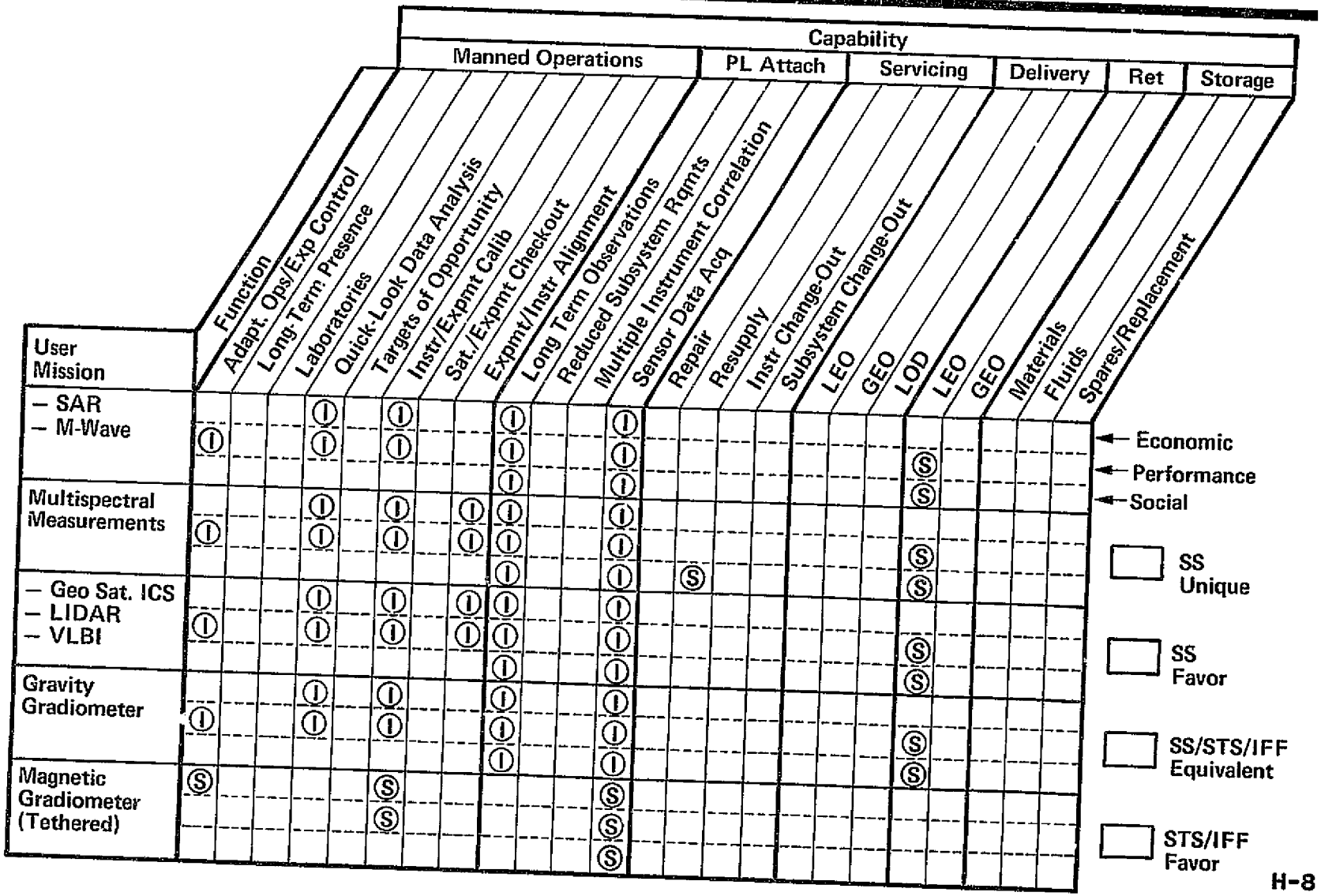

SPACE STATION
CAPABILITIES
FUNCTIONS
USER MISSIONS
PROGRAM OPTIONS
A-1 B-1
A-2 B-2
A-3 B-3
A-4 C-1
ANALYZE & ASSESS BENEFITS
– ECONOMIC
– PERFORMANCE
– SOCIAL
PROGRAM OPTION A-1
"ACCRUED BENEFITS SUMMARY"
– TIME PHASED
SPACE STATION BENEFITS SUMMARY
COST/BENEFIT ANALYSIS

Accrued Benefits Summary





S-2 Earth Observation



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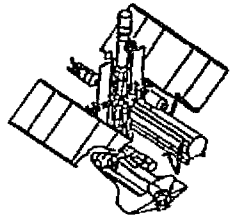
Earth Observation Accrued Benefits



Space Station Unique

- Targets of Opportunity (E,P,S)
- Reduced Subsystem Requirements (E,S)
- Multiple Instrument Correlation (E,P,S)
- Tethered Satellite LOD (E,P,S)
- On-Orbit Storage of Space/ Replacements Parts (E,P)
- On-Orbit Storage of Required Fluids (E,P)
- Long Term Manned Presence (S)

Space Station Favored

- Manned Laborabories (E,P,S)
- Sat/Expmt Check-Out (E,P,S)
- Servicing (E,P)
  - Repair
  - Resupply
  - Instr./Subsystem Changeout
- Reduced Subsystem Reqmts for Tethered Satellite (E,S)
- Quick-Look Data Analysis for Tethered Satellite (E,P,S)

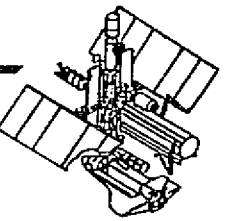
Space Station/STS or IFF Equivalent

- Long Term Sensor Observations (E,P,S)
- Sensor Data Acquisition (E,P,S)
- Quick-Look Data Analysis (E,P)
- Instrument Calibration (E,P)
- Instrument Alignment (E,P)
- LEO Retrieval (P,S)

Space Station Unfavorable

- LEO Delivery (P)
- Manned Adaptive Expmt/Opns. Control
- Long Term Manned Operations (Per Independent Mission)

Mission Requirements Summary



User Missions

- Categories Identified (27)
- Contact Plan Completed (60%)
- User Mission Concepts Prepared (40+)
- 20-Yr Plans Baselined

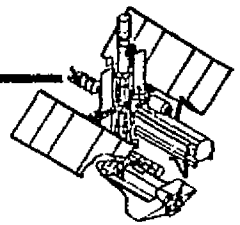
Requirements Analysis

- Composite Mission Model Baselined (290)
- User Accommodation Document Drafted
- Initial SS/STS/IFF Mission Relationships Established
- Alternate Mission Parametrics

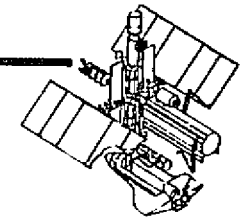
Accrued Benefits

- Benefits & Activities Baselined (15%)

Agenda



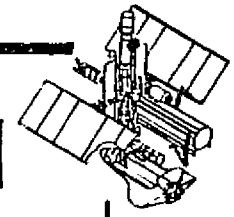
SUBJECT	SPEAKER
Introduction	R. B. Demoret
Executive Summary	S. R. Schrock
Mission Requirements	T. J. Sullivan
- User Mission Requirements Development	F. J. Steputis
- Astronomy/Space Physics/Planetary	F. Bartko
- Solar Physics/Earth Observations	S. M. Pompea
- Comm./Life Sci./Mtls Proc./Commercial	W. O. Nobles
- Space Station and User Requirements Analysis	G. E. Stone
- Accrued Benefits	T. J. Sullivan
Mission Implementation Concepts	T. J. Rasser
Cost, Schedule, and Benefits Analysis	T. A. Mottinger
DOD Tasks	T. K. Sulmeisters
Adjournment	



Mission Implementation Concepts

Tom Rasser

Space Station Study Flow



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Science | Applications | Commercial | Space Ops | National Security | Foreign User*

*Integrated by NASA

1982 — Time-Phased Objectives — 2000

User Rqmts Validation
- USRA
- Scientist
- NASA
- Ball
- Infotech
- Etc

Benefits
- Social
- Economic
- Performance

Consolidated Discipline Rqmts ↔ Operational Requirements

- Service
- Assembly/ Construction
- Delivery/ Retrieval
- Etc

STS/SS/IFF Analysis | Technology Assessment

Mission Functional Analysis Accommodations

User Mission Reqmts
- Solar
- Astronomy

Technology Development Reqmts & Plan
- Large Structure Assy
- Thermal Control
- Attitude Control
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Iteration

Integrated User Mission Reqmts

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Program Options
- Single Station
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Space Station Support Reqmts

Arch. Option to Support Program Options

Cost, Schedule & Benefits Analysis

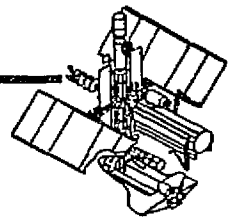
Element Definition & Characteristics

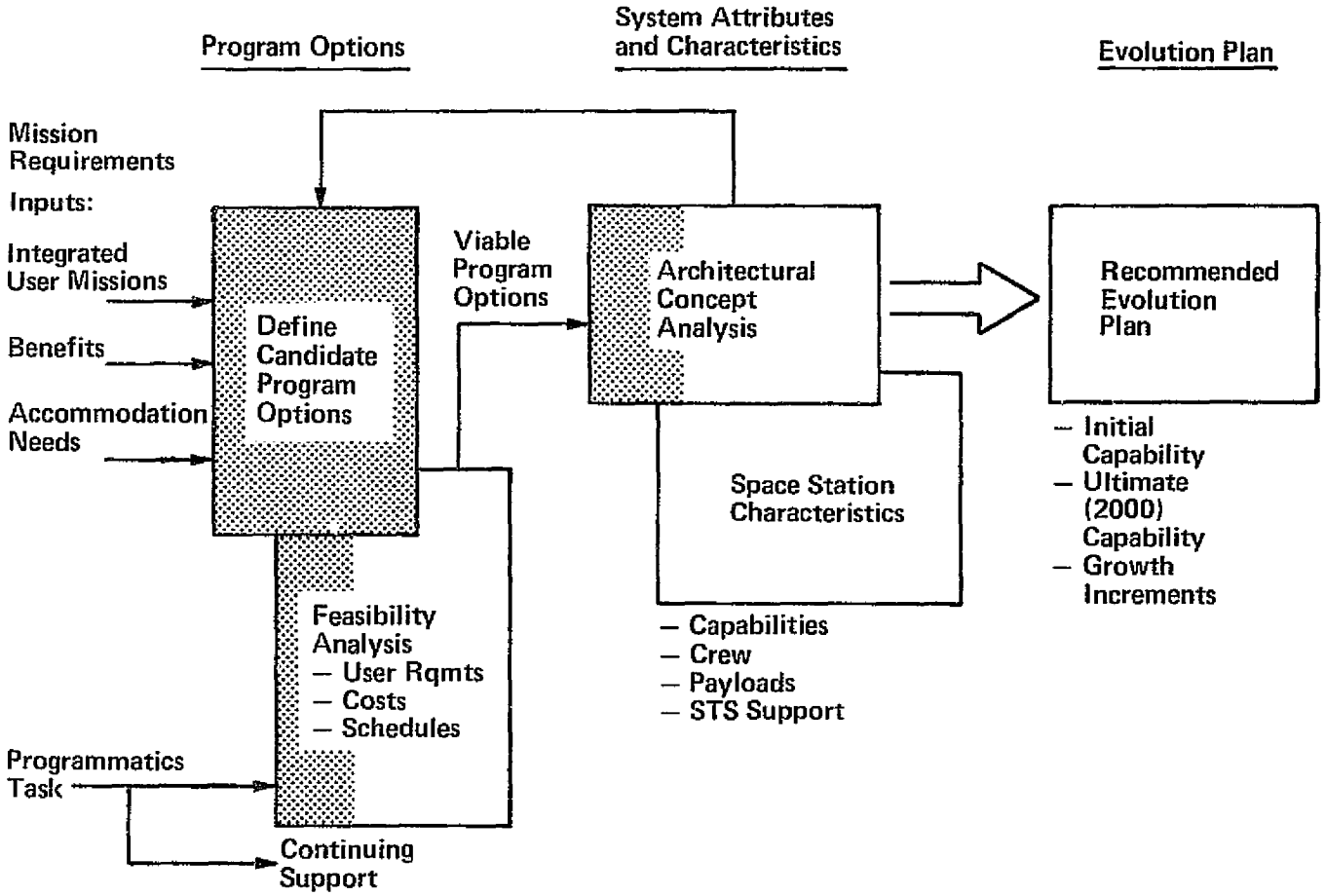
Recommend Space Station Architectural Concept/Attributes → Initial Capability → Growth Increments → Ultimate Capability

REQUIREMENTS TRACEABILITY

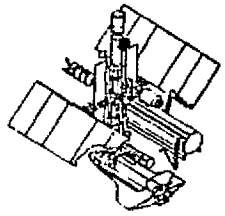
I-2

Implementation Concepts Flow Diagram





Program Options



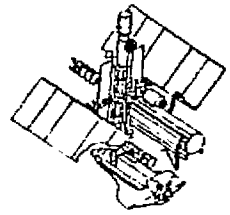
DEFINITION - TOP LEVEL PLAN FOR IMPLEMENTING AND EVOLVING SPACE STATION CAPABILITIES BASED ON USER REQUIREMENTS. DEFINES:

- MAJOR SPACE STATION CAPABILITY MILESTONES
- REQUIREMENTS RATIONALE
- STS AND ELV SUPPORT

APPLICATION -

- INITIAL STEP IN DERIVING ARCHITECTURAL OPTIONS
- BASIS FOR EVOLUTION PLAN
- ALLOWS ITERATION BETWEEN REQUIREMENTS/ARCHITECTURE/ PROGRAMMATICS
- ANSWERS:
  - WHAT CAPABILITIES ARE NEEDED?
  - WHERE ARE THEY MOST BENEFICIAL?
  - WHEN IMPLEMENTED?
  - WHAT IS COST?

Candidate Program Options



CATEGORY A - SINGLE MANNED SPACE STATION PLUS UNMANNED PLATFORMS

- A-1 - 28^{o} STATION, EARLY OTV
- A-2 - 28^{o} STATION, LEO SUPPORT
- A-3 - 50^{o} - 57^{o} STATION
- A-4 - 90^{o} STATION

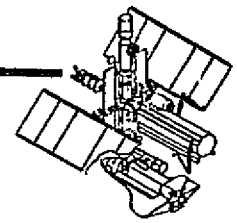
CATEGORY B - TWO MANNED SPACE STATIONS PLUS UNMANNED PLATFORMS

- B-1 - INITIAL STATION AT 28^{o}
- B-2 - INITIAL STATION AT 90^{o}
- B-3 - SHUTTLE DERIVED VEHICLE

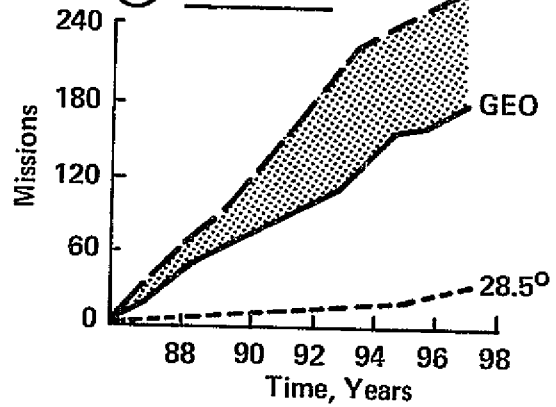
CATEGORY C - SPECIAL EMPHASIS

- C-1 - LOW FRONT END COST

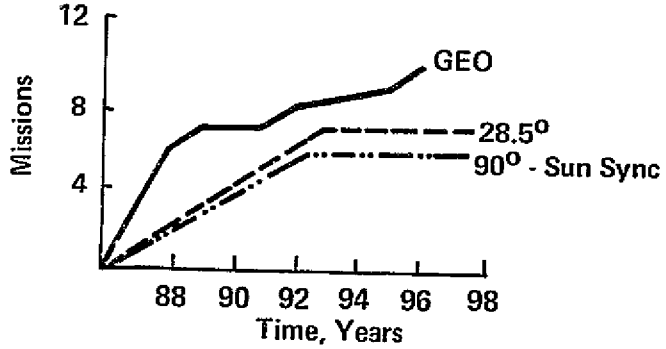
Requirements Data Base



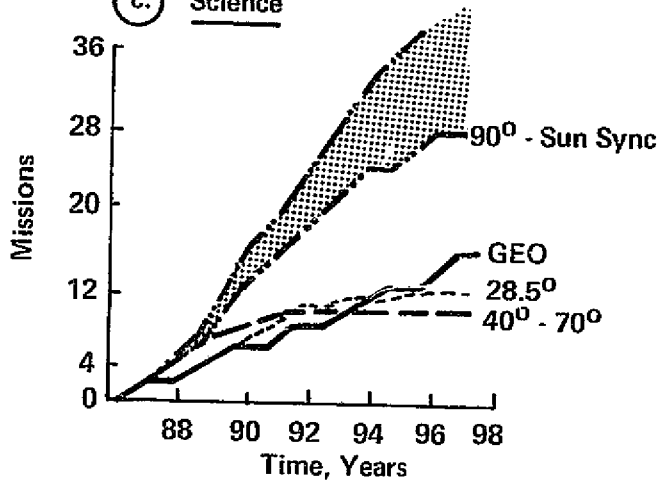
a. Commercial



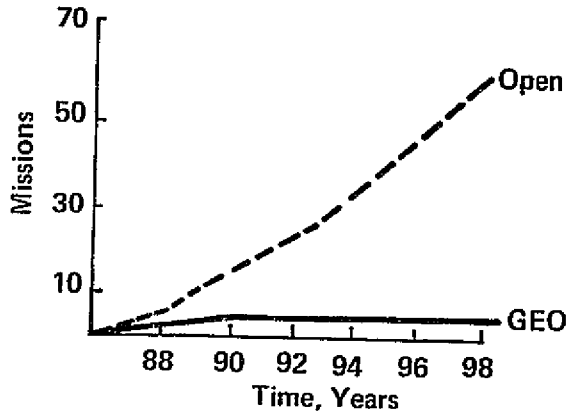
b. DOD



c. Science



d. Applications



290 User Missions ⟶ 400-450 Flights

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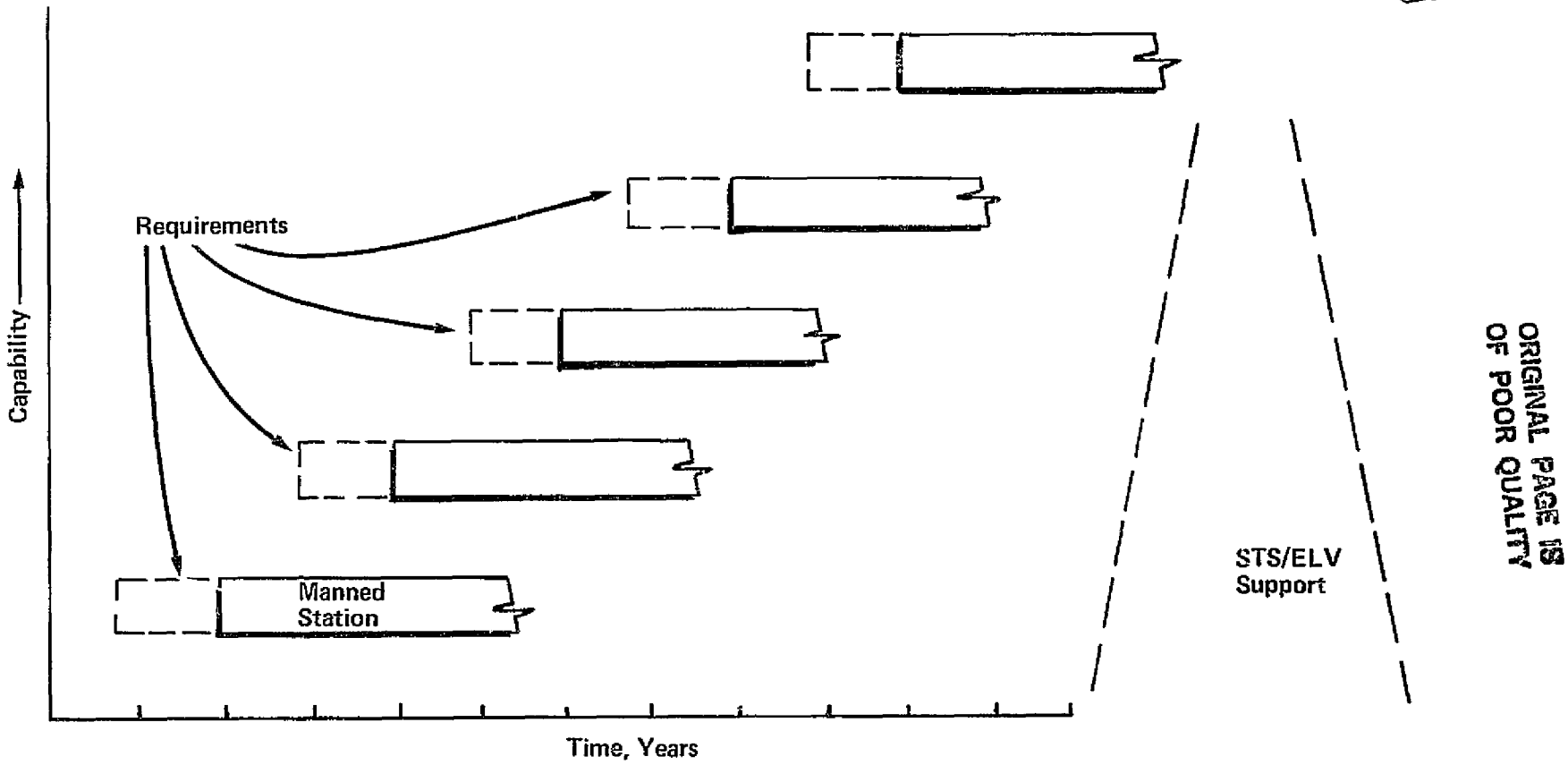
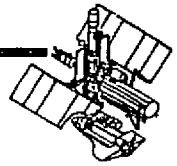
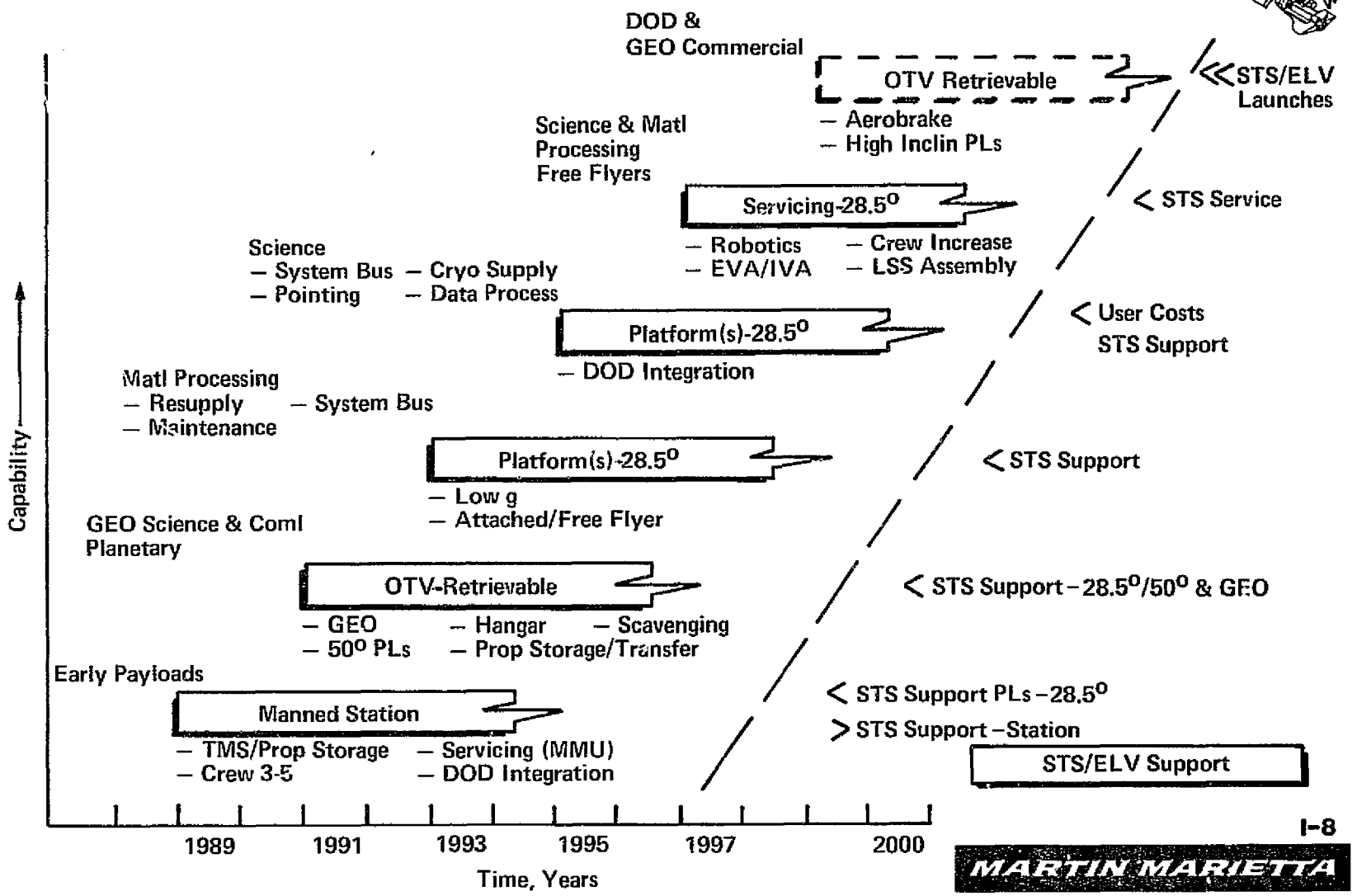
Program Option Format



Option A-1: 28.5°-Early OTV





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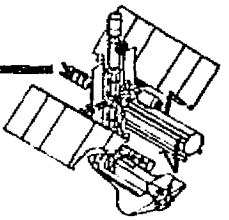
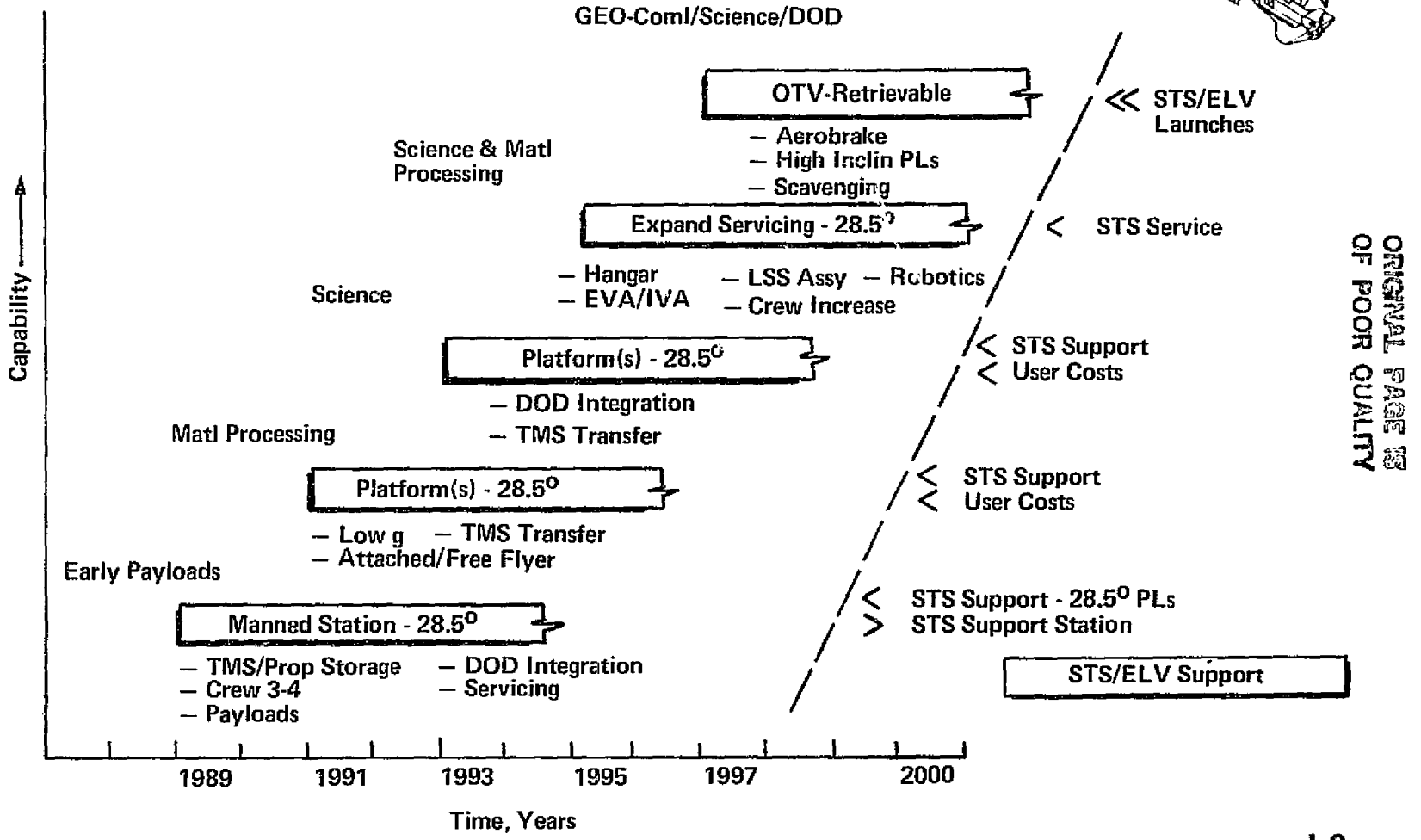
Option A-2: 28.5° LEO Support





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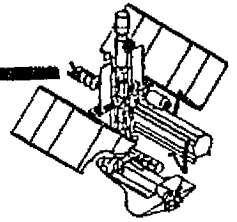
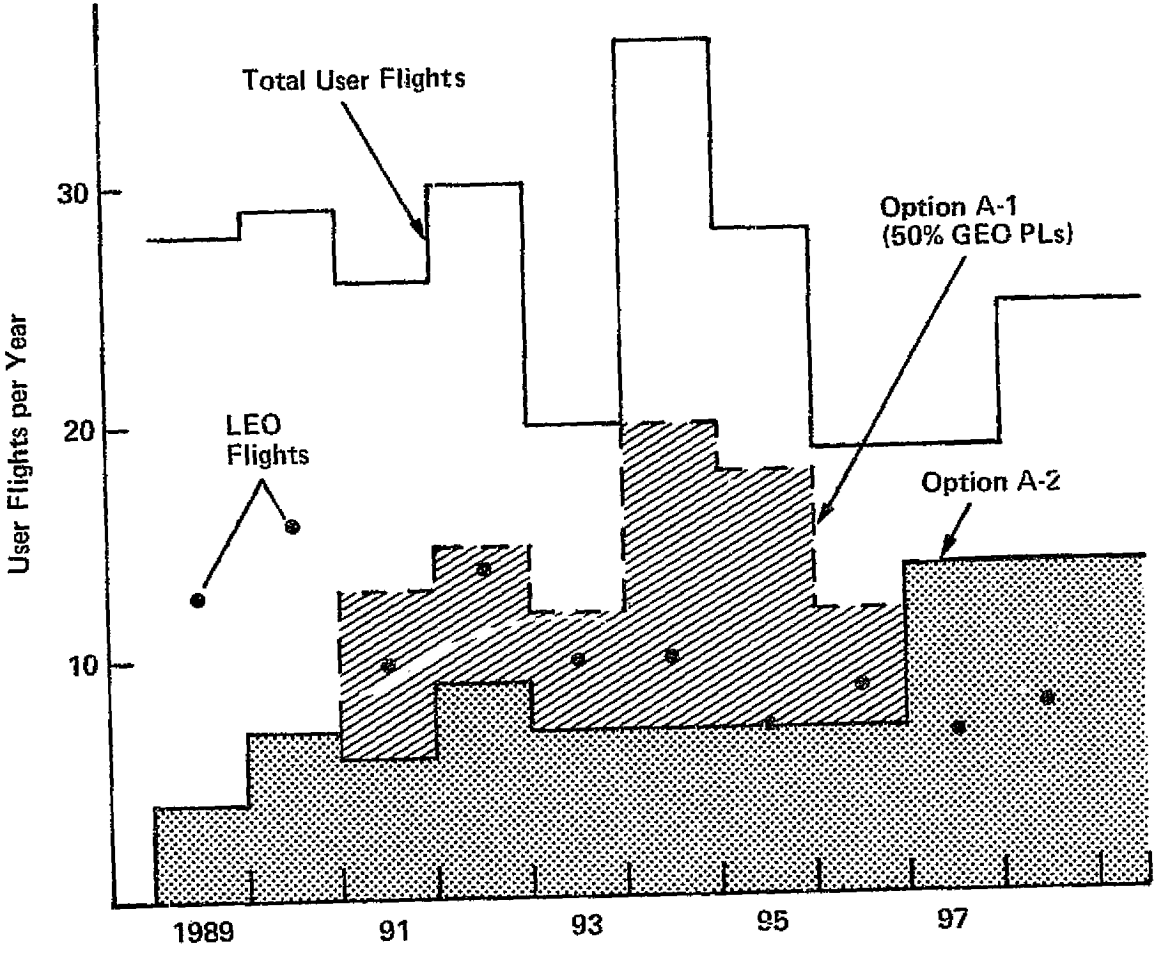
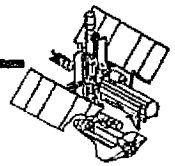
User Capture Analysis

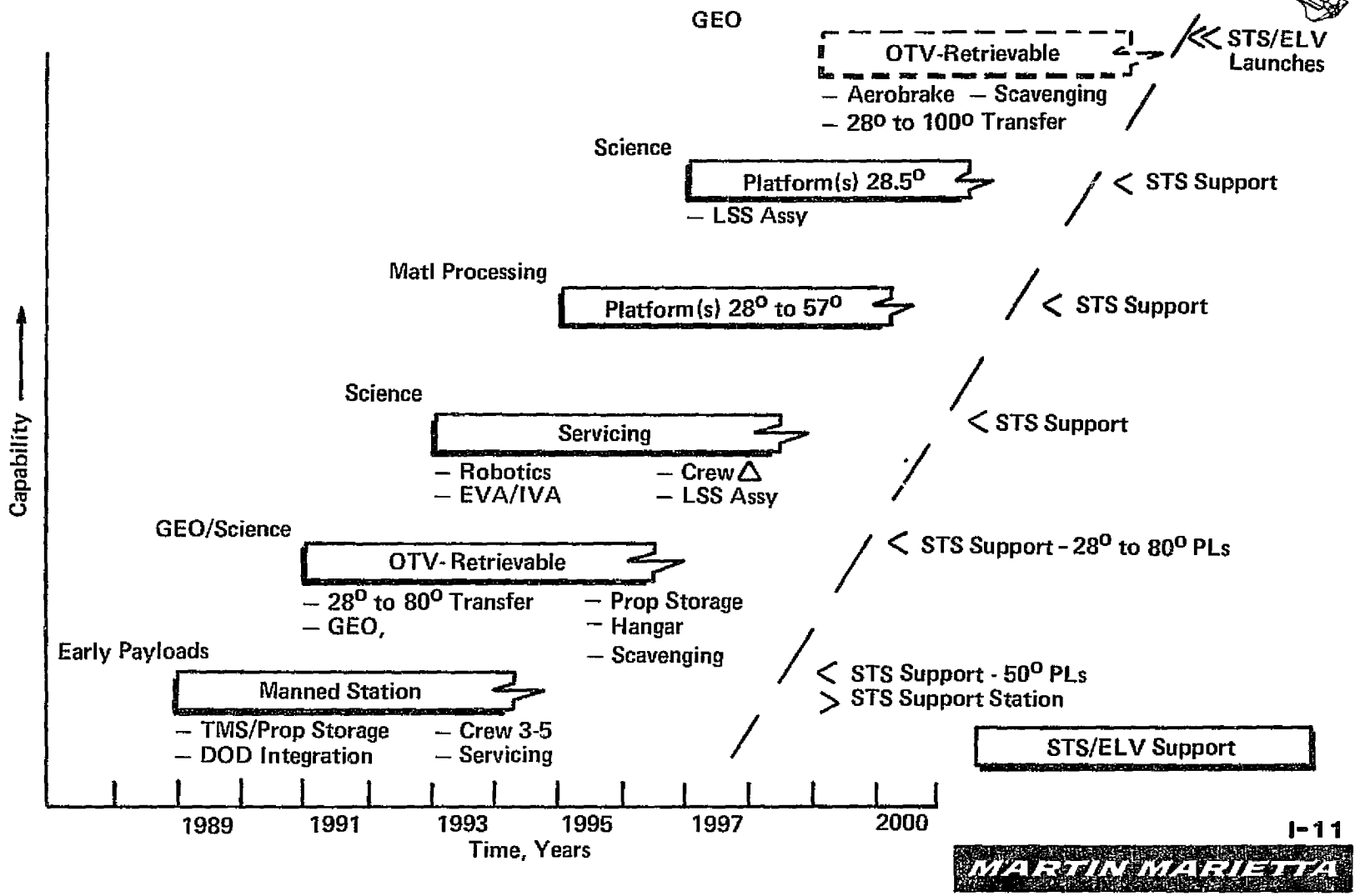




Cumulative Flights		
Yr	A-1	A-2
89	4	4
90	11	11
	24	17
92	39	26
	51	33
94	71	40
	89	47
96	101	54
97	115	68
	49%	29%

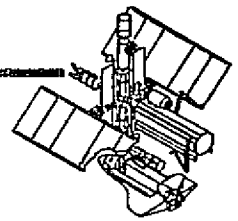
Option A-3: 50° to 57° Station

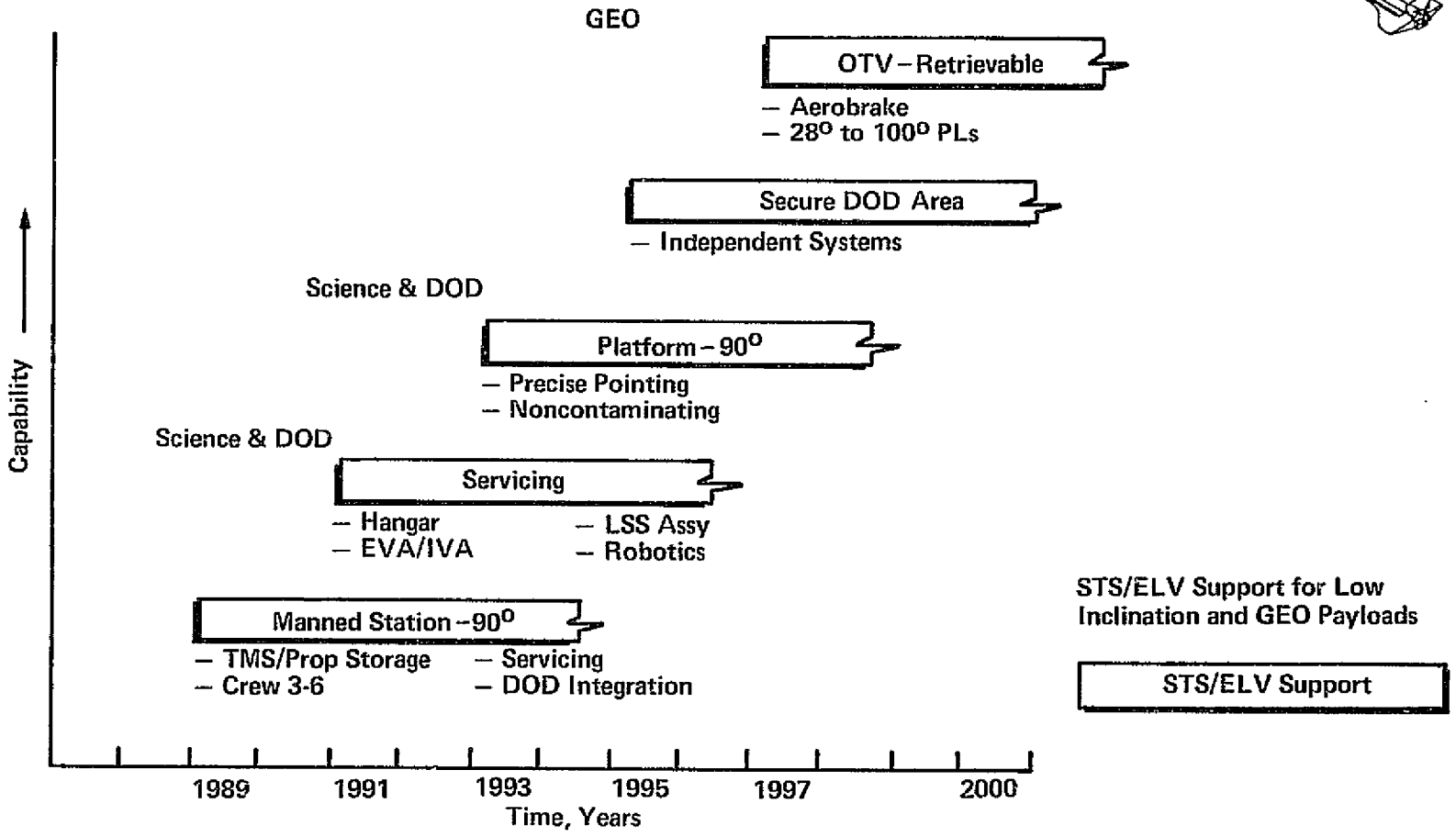




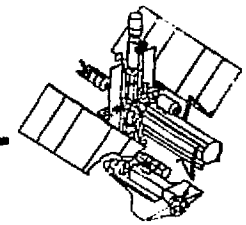
MARTIN MARIETTA

Option A-4: 90° Station





Option B-1: 28.5° → 90° Stations



GEO

OTV Retrievable - 28°

≪ STS & ELV Launches

– Prop Storage/Scavenging
– Crew △ – High Inclin PLs

Science

Servicing - 90°

< STS Service

– Hangar – LSS Assy
– EVA/IVA – Crew
– Robotics

Science & DOD

Manned Station - 90°

< Support - 90° PLs
> STS Support Station

– TMS – DOD Secure
– Crew 3-5 – Servicing

Matl Processing & Science

Servicing - 28.5°

– Hangar – LSS Assy
– Robotics – EVA/IVA
– Crew

Matl Processing

< STS Support
< User Costs

Platform - 28.5°

– Low g

Early Payloads

Manned Station - 28.5°

< STS Support - 28.5° PLs
> STS Support - Station

– TMS/Prop Storage – Servicing
– Crew 3-5 – DOD Integ

STS/ELV Support

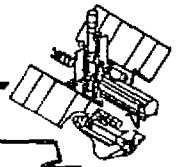
Capability →

1989 1991 1993 1995 1997 2000

Time, Years

MARTIN MARIETTA

Option B-2: 90° → 28.5° Stations



GEO

OTV Retrievable – 28.5°

– Aerobrake – Scavenging
– High Inclin PLs

Science

Platform(s) – 28.5°

– Precise Pointing
– LSS Assy

Science & Matl Processing

Servicing – 28.5°

– Hangar – LSS Assy
– EVA/IVA – Robotics

Science

Manned Station – 28.5°

– TMS – DOD Secure
– Crew 3-6

STS/ELV Support Levels Similar to Option B-1

Science & DOD

Servicing – 90°

– EVA/IVA – LSS Assy
– Robotics – Crew Increase

Science & DOD

Manned Station – 90°

– TMS/Prop Storage – Servicing
– Crew 3-4 – DOD Integ

Matl Processing

Platform(s) – 28.5°

Low g

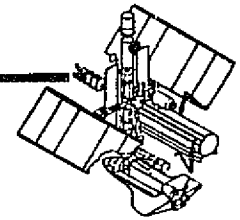
STS/ELV Support

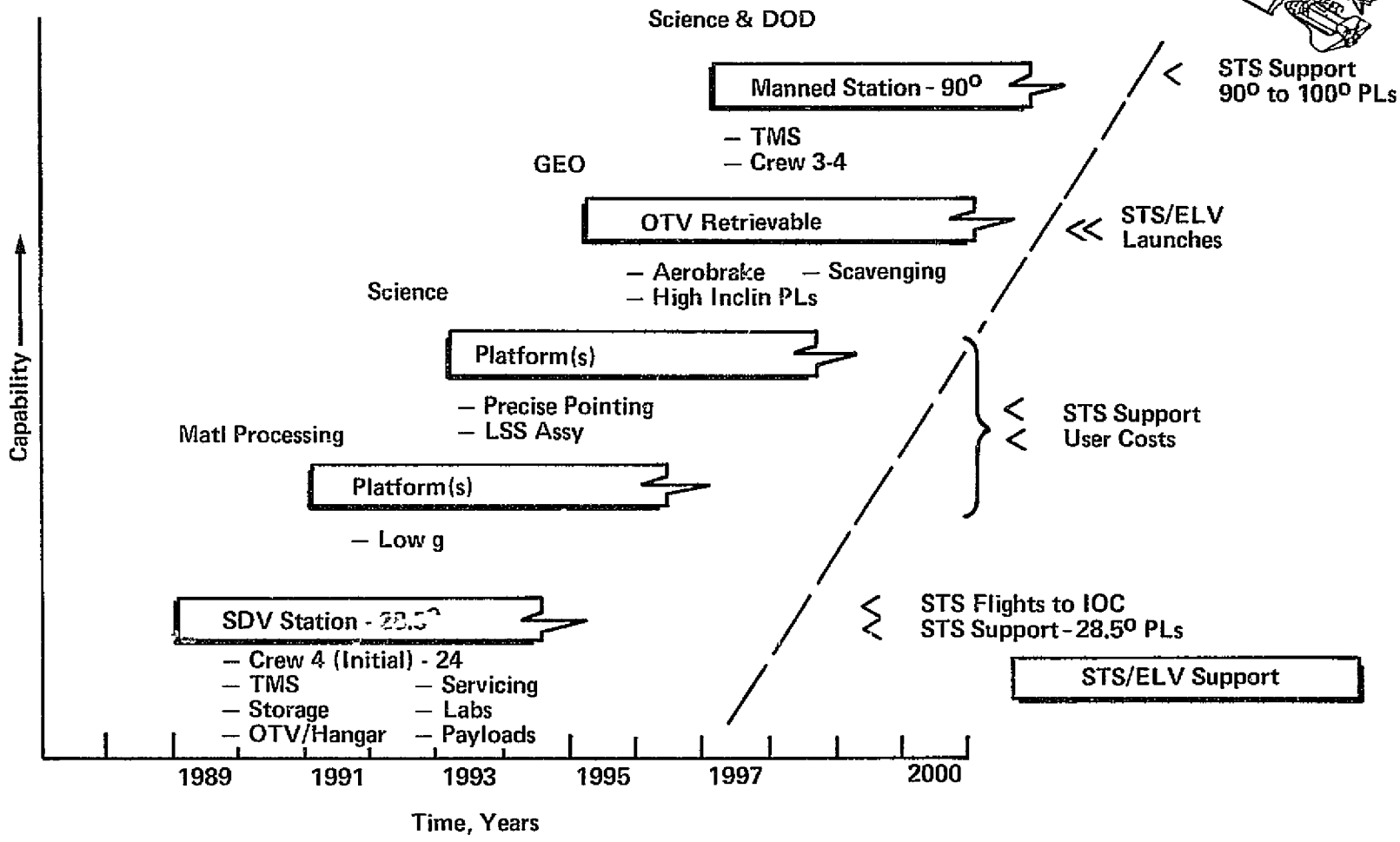
Capability →

1990 1992 1994 1996 1998 2000

Time, Years

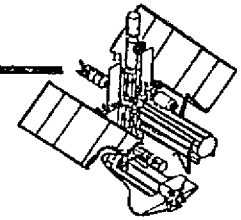
Option B-3: Shuttle-Derived Vehicle Station



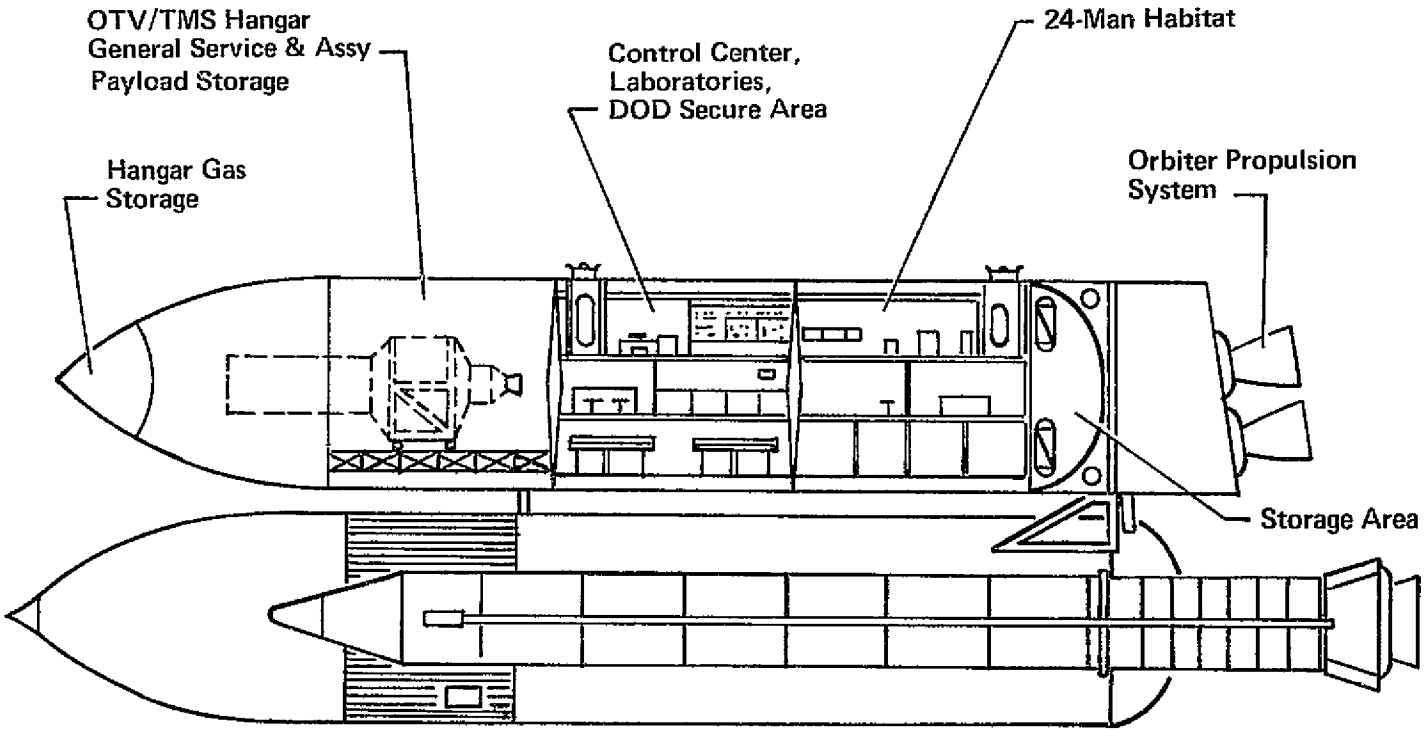


MARTIN MARIETTA

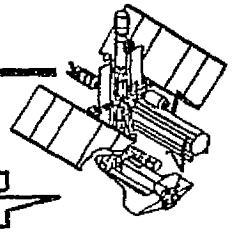
Shuttle-Derived Space Station



60,000 ft^3 Useable Volume/One STS Launch



Option C-1: Low Front-End Cost



GEO

OTV Retrievable-28.5°

- Aerobrake
- High Inclin PLs —Scavenging

Matl Processing or Science

Platform(s)-28.5°

- System Support

Servicing-28.5°

- Hangar
- EVA/IVA
- LSS Assy
- Robotics

Matl Processing, Science, DOD

Manned Station-28.5°

- TMS
- Crew 4-8
- Servicing
- DOD Integ

Science

Platform(s)-28.5°

Matl Processing

Platform(s)-28.5°

- Low g

STS/ELV Support

- Reduced STS Support at 28.5°
- Reduced ELV Support to GEO
- STS Supports High Inclin PLs

Capability

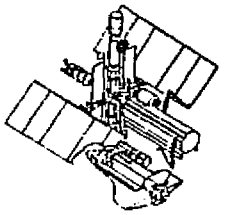
1989 1991 1993 1995 1997 2000

Time, Years

ORIGINAL PAGE IS OF POOR QUALITY

MARTIN MARIETTA

Mission Implementation Summary

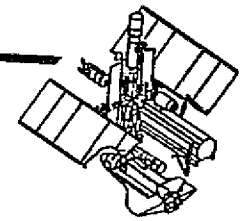


- USER REQUIREMENTS IMPLY NEED FOR A COMBINATION OF MANNED AND UNMANNED SPACE STATION CAPABILITIES.

- PRELIMINARY RESULTS INDICATE THAT EARLY DEPLOYMENT OF MAN IN SPACE:
  - IS MANDATORY FOR LONG TERM LIFE SCIENCES REQUIREMENTS.
  - ENHANCES PERFORMANCE OF COMPLEX OPERATIONS ASSOCIATED WITH USER SUPPORT.
  - RESULTS IN ECONOMIC AND PERFORMANCE BENEFITS TO LARGE NUMBER OF FREE-FLYER PAYLOADS.

- SECOND MANNED SPACE STATION IS REQUIRED AT SOME FUTURE TIME TO MAXIMIZE USER SUPPORT.

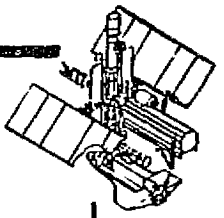
- BENEFITS DERIVED FROM MANNED SPACE STATION ARE GREATER FOR FREE-FLYING PAYLOADS/PLATFORMS THAN FOR ONBOARD OR ATTACHED PAYLOADS.



Cost, Schedule, and Benefits Analysis

Tom Mottinger

Space Station Study Flow



From User Communities

Science | Applications | Commercial | Space Ops | National Security | Foreign User*

*Integrated by NASA

1982 — Time-Phased Objectives — 2000

User Rqmts Validation
- USRA
- Scientist
- NASA
- Ball
- Infotech
- Etc

Consolidated Discipline Rqmts ↔ Operational Requirements

- Service
- Assembly/ Construction
- Delivery/ Retrieval
- Etc

Benefits
- Social
- Economic
- Performance

STS/SS/IFF Analysis | Technology Assessment

Mission Functional Analysis Accommodations

User Mission Reqmts
Solar
Astronomy

Technology Development Reqmts & Plan
- Large Structure Assy
- Thermal Control
- Attitude Control
- Etc

Iteration

Integrated User Mission Reqmts
SS Mission Model

Detailed Reqmts Definition

Program Options
- Single Station
- Multiple Stations
- Low Early Cost
- Etc

Space Station Support Reqmts

Arch. Option to Support Program Options

Cost, Schedule & Benefits Analysis

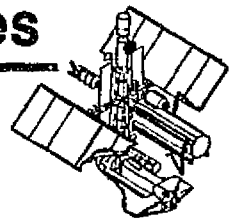
Element Definition & Characteristics

Recommend Space Station Architectural Concept/Attributes → Initial Capability → Growth Increments → Ultimate Capability

REQUIREMENTS TRACEABILITY

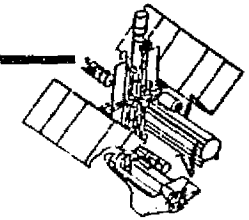
J-2

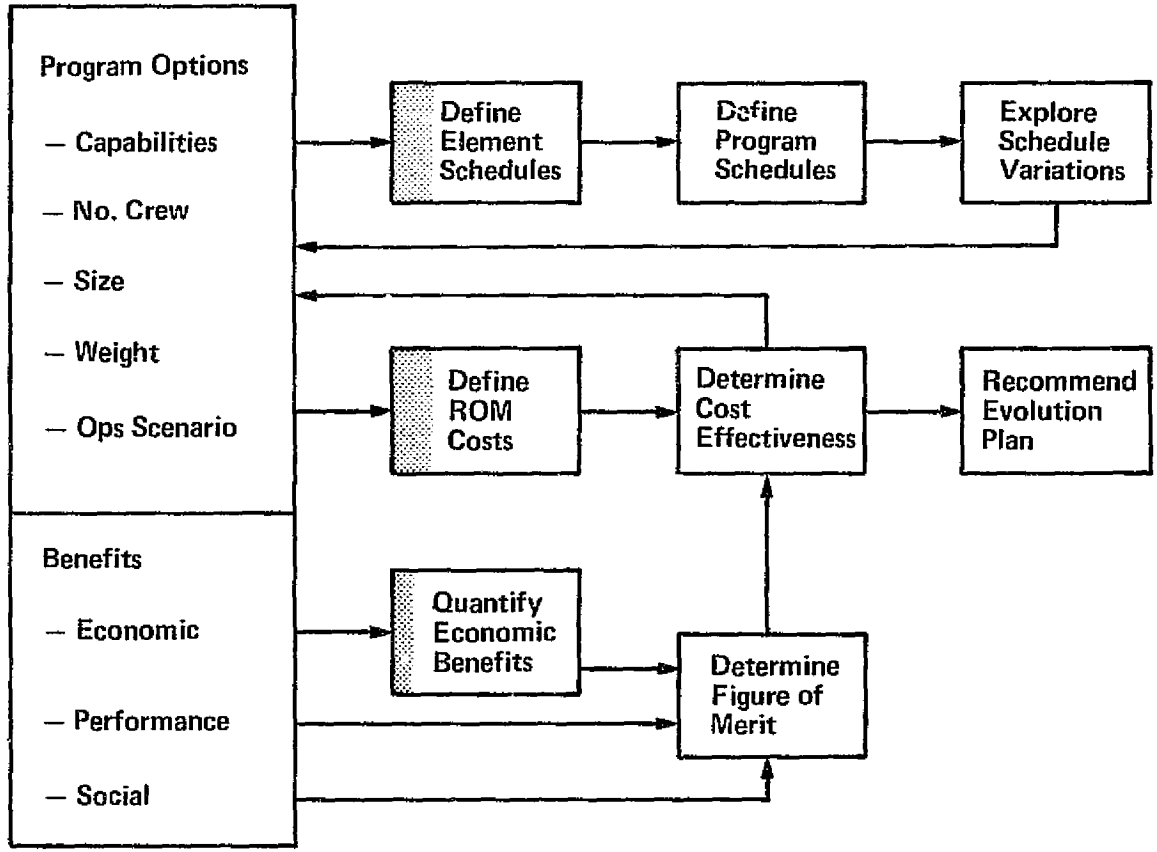
Cost, Schedule, and Benefits Analysis Objectives



- DEFINE THE ROM COSTS AND SCHEDULES FOR SPACE STATION OPTIONS.
- DEVELOP METHODS AND CONDUCT ANLAYSES TO DETERMINE ROM COSTS AND BENEFITS OF EACH PROPOSED CAPABILITY INCREMENT.
- COMPARE COSTS AND BENEFITS TO DETERMINE A COST-EFFECTIVE EVOLUTION PLAN.
- EXPLORE THE EFFECT OF SCHEDULE VARIATION ON COSTS AND BENEFITS.

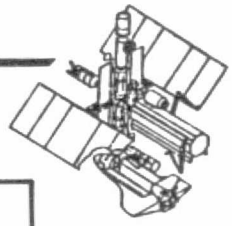
Task Overview and Status



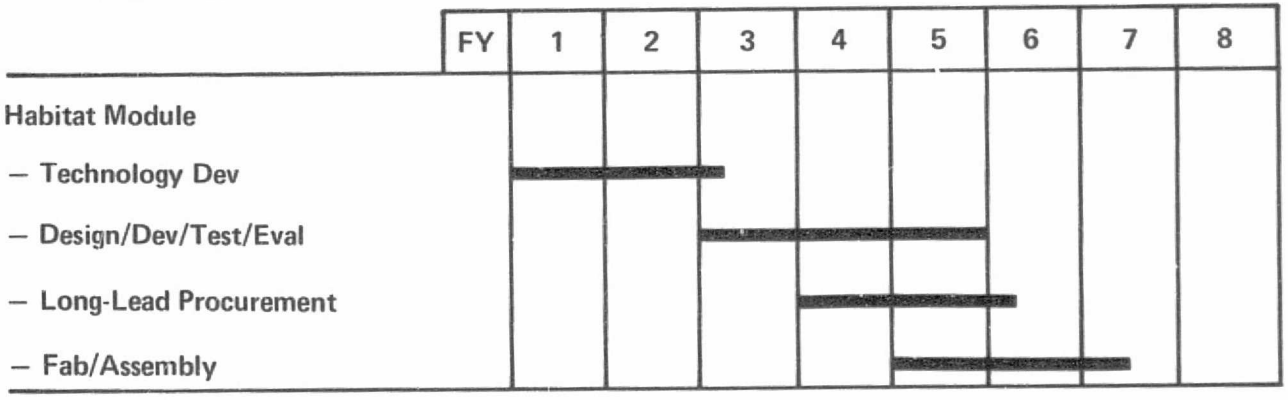


MARTIN MARIETTA

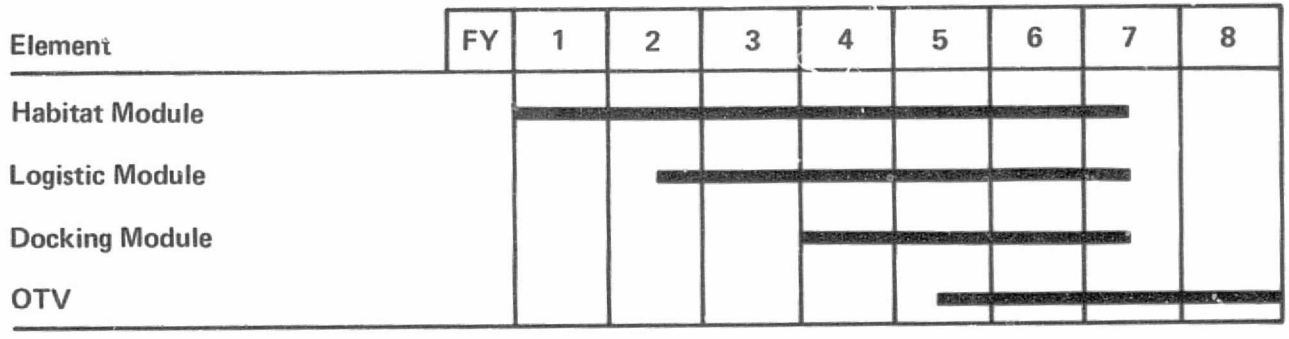
Schedule Analysis Example



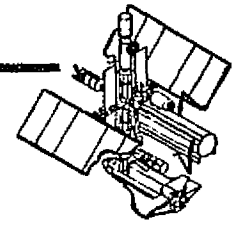
Element Schedules



Program Schedules



Cost Estimate Approach



Space Station Element Characteristics

- Dimensions
- Weight
- Performance
- No. Crew
- Logistics Requirements
- Shuttle Resupply Flights

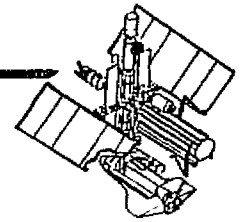
Cost-Estimate Methods

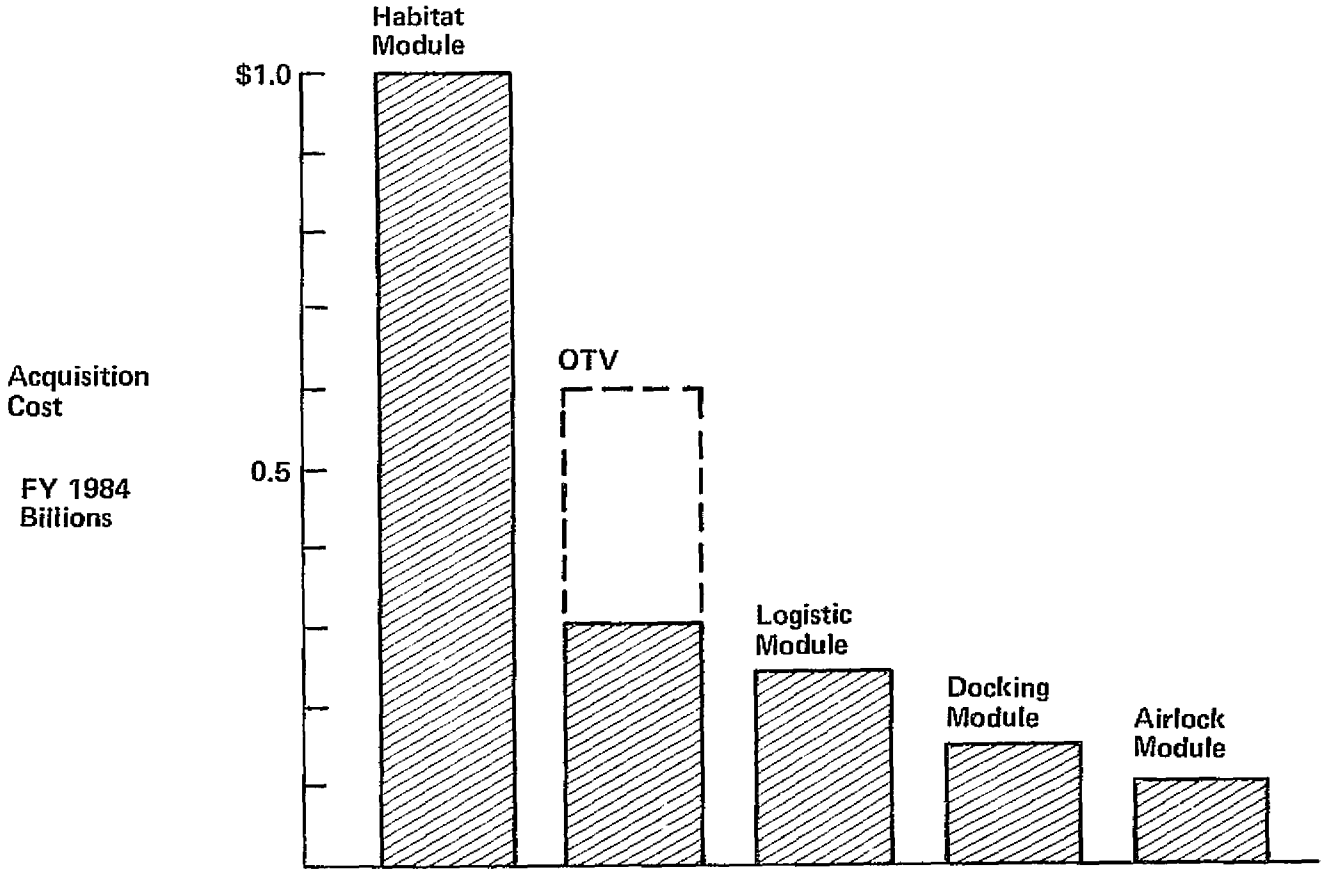
- Analogies
  - Skylab
  - Spacelab
  - Shuttle
- Parametric
  - CERs
  - Models
- Project Data
  - STS User Charges
  - MMU
  - TMS
  - OTVs

ROM Costs

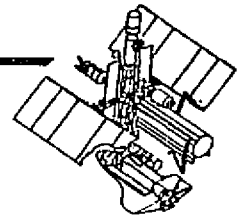
- DDT&E
- Production
- O&S

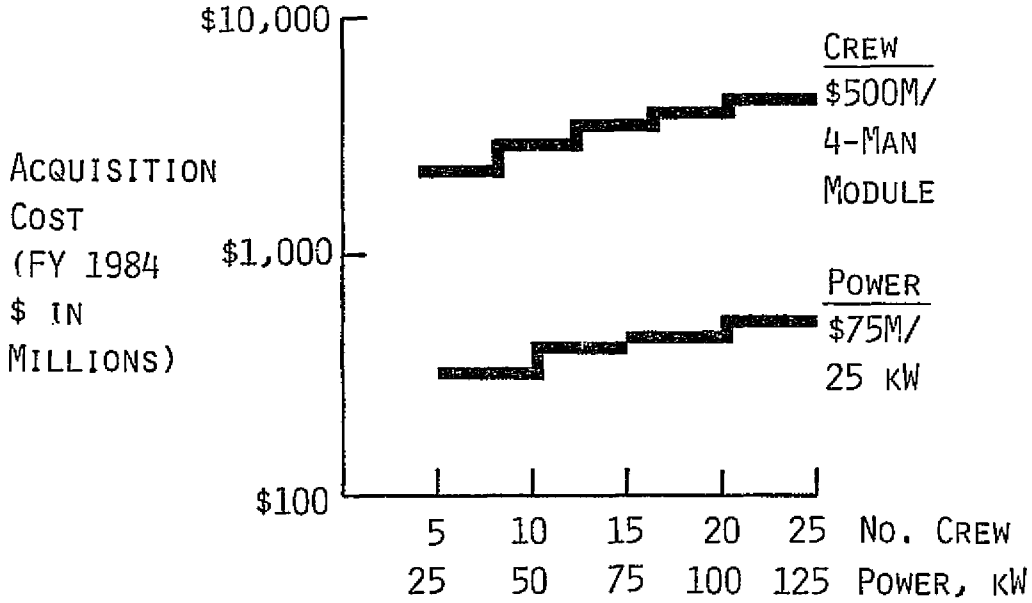
ROM Space Station Element Costs





Cost vs Capability Increment

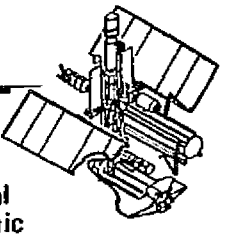




In Work -
Cost vs Number of Users:

- Delivered
- Serviced
- Retrieved
- Stored

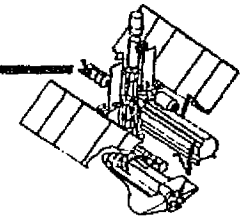
Quantification of Economic Benefit Example

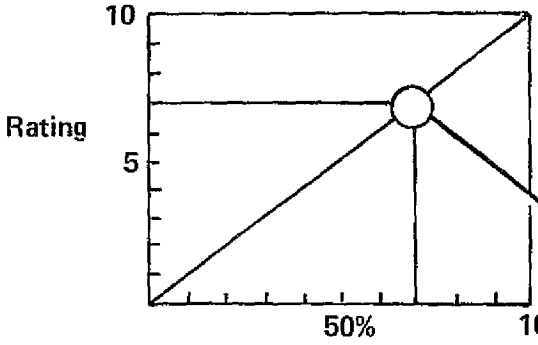


Economic Benefit				Typical Spacecraft Subsystem Breakdown[2]			Potential Economic Benefit
Payload Attached — Delete Spacecraft Subsystems				Structure	9%		
				Propulsion	5%		
				G&C	9%		
				Comm	14%	41% x 75% = 31%	
				Power	4%		
LIDAR — Weight 1835 lb	CERs[1]	N/R	$180M	Science	16%		
		R	$ 70M	Subtotal	57%		54% of $250M = $135M
		Total	$250M	Management	5%		
				Systems	4%		
				Test	7%	43% x 54% = 23%	
				Q/C-Rel	5%		
				Assembly	3%		
				GSE	9%		
				Launch/Flight Ops	10%		
				Subtotal	43%		
				Total	100%		

Note:
1. Martin Marietta cost-estimating relationships. 2. SAI spacecraft cost model.

Program Option Decision Matrix Example

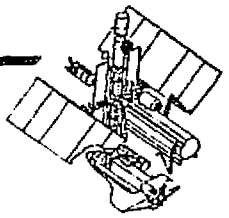




Program Option	Wt	Benefits: Economic	Benefits: Performance	Benefits: Social	Figure of Merit	Program Cost	FOM/Cost
		5	3	2			
A-1		7	5	8	66	$10.1	6.53
A-2		6	8	5	64	$ 9.8	6.53
A-3		4	3	7	43	$ 9.7	4.43
A-4		7	6	5	63	$ 9.9	6.36
B-1		10	7	8	87	$12.2	7.13
B-2		8	10	6	82	$12.0	6.83

Select Program Option with Largest Ratio

Cost, Schedule And Benefits Analysis–Status



COMPLETE

- FIRST CUT AT ROM COSTS AND SCHEDULES FOR SPACE STATION ELEMENTS
- METHODS TO EVALUATE PROGRAM OPTIONS

EFFORT REMAINING

- REFINE ROM COSTS AND SCHEDULES
- QUANTIFY ECONOMIC BENEFITS
- EXPLORE EFFECT OF SCHEDULE VARIATIONS
- SELECT A COST EFFECTIVE EVOLUTION PLAN